Autonomous Surface Vehicle for RoboBoat Competition

Micah Healy, Kyle Houchin, & John McIntosh

South Dakota School of Mines and Technology

ABSTRACT

In this paper, we will discuss the design and development of an ASV (autonomous surface vehicle). We designed the ASV to navigate a series of challenges set forth by robonation in their roboboat competition. These challenges focus on autonomous guidance, navigation and control for which we are using skills like image processing, pathing, and obstacle avoidance. We will also discuss the design and testing of the electrical, mechanical, and software systems involved in the ASV.
Keywords: ASV, roboboat, design

1. Competition Strategy

As we are a new team with limited time and resources we decided to focus our time on completing the navigation tasks namely the navigation channel, avoid the crowds, and possibly the speed gate.

1.1 Approach

Our approach to this competition was to minimise the complexity of our ASV while maximising the number of tasks we can complete. This was the reason we choose to focus on the navigation tasks, as we reasoned that they would all likely use similar sensors, and a lot of the code could be reused. subsectionVehicle Design

1.2 Discussion

As discussed earlier we primarily aimed at a simple system. Minimising the complexity as much as possible while still achieving our goals. Though we could have cut a few more tasks we reasoned that they would not add to much complexity and that if necessary we could always cut them out later if they became to much.

1.3 Strategic Vision

Our team as a whole was fairly inexperienced. We had never participated in this competition and our team was almost entirely underclassmen. Due to these factors our strategic vision was to build a functional boat which could complete 1 or 2 obstacles and put up a decent showing. We wanted to do this so that we could; boost team moral, gain knowledge of the course and have something to show potential supporters. We wanted to be able to take a team down to Florida as it would encourage the team as they could see the fruits of their labor. It would also allow us to see other teams strategy, the organisation of the competition, and network with other teams. The last reason is financial if we can show physical results it will encourage our supporters to continue to support us

2. Design Creativity

From the system level down most of the ASV was completely original we had very little past work to reference and did not reference many other teams work. We did however use many of the shelf sensors and micro controllers as that allowed us to manufacture the boat in a realistic time frame

2.1 System Architecture

Our overall system was unique using many different microprocessors. These included an Arduino MEGA for collecting sonar data, two Arduino UNOs, one for the remote, one for the LIDAR, a Jetson Nano for image collection and processing of two pi cams, and a Raspberry Pi for navigation and motor control.

The data from the 10 sonar sensors and the LIDAR are sent to the Jetson Nano for sensor fusion. This is sent over serial as it's the easiest to send. The Jetson then takes pictures from the two cameras and combines all the sensor information and image information into a single local map. This holds any game objects that the cameras pick up as well as their distances collected through the LIDAR. If one of the game pieces gets too close to the ASV the sonars will detect it and the local map will record it.

The local map is then sent from the Jetson to the raspberry pi, through an Ethernet cable. This allows for fast two-way communication. Having the sensor fission done on the Jetson Nano frees up the load on the raspberry pi. Allowing the response rate to obstacles to be faster. The raspberry takes the local map and combines it into a world map that holds all the information on where the ASV is in relation to previously detected game objects and current items around it. Allowing for short and long-range navigation.

2.2 Obstacle Avoidance

Most of the Obstacle Avoidance is handled with the local map. The local map is all the objects or buoys that the cameras, LIDAR, and sonar sensors pick up at one time. This does not include buoys that have left the field of view of the ASV Or noise from the last collection. For each buoy color, the center positions that is relative to the start, and accurate predictions are recorded. As the cameras or LIDAR detect the buoy the accuracy goes up. This is the probability that The "buoy" is actually a buoy and not some noise from one or two of the sensors. If the camera and LIDAR fail to detect an object the 10 sonars sensors positioned in various locations around the ASV will detect it and the ASV will make evasive actions.

2.3 Navigation Control

For long range navigation a world map is created. This uses every local map that has been collected and meshes it together into a single map. The world map also allows for better position tracking of the ASV as we are not using GPS or other position tracking electronics. As the boat moves the cameras will track all the buoys in sight and with the LIDAR and IMU will predict the velocity and acceleration. This is used to advance the predicted position, allowing for challenges like return to Home without running into a pre-found collection of buoys.

3. Experimental Results

We were have not completed the code and the boat at the time this report was written. Due to this we have not completed any physical testing. It would have been better to do testing earlier but due to many administration complications it did not happen. We will talk about some of our planned testing and the software simulation that we did.

3.1 Out-of-water Obstacle Detection

One proposed test is to set up obstacles out of the water and see how well the system could detect obstacles and look at the outputs of the system.

3.2 In-water Testing

To test the system in the water the plan is to simply set up the challenge that we wish to test, use tele-op to drive the ASV to a start location and switch the system back into to autonomous mode and switch the system back to tele-op if any problems are encountered.

4. Acknowledgements

We would like to thank the entire South Dakota Mines campus and community for their support. The ME faculty especially Dr. Hadi Fekrmandi for his support and encouragement throughout the project, and Dr. Arron Lalley for his support in the use of the various shops on campus. We would also like to thank all those who helped us set up our club and secure funding namely Cory Headley, Cooper Emery, and Michael Keegan. We would also like to thank Perry Ketelsen for her help in designing our logo. Finally, we would like to thank our sponsors including SD Mines, C.R. Fischer and sons, Pita Pit/Therese Rowland and The Monument.

APPENDIX

A: Component Specifications

Component	Vendor	Model/Type	Specs	Custom/Purchased	Cost	Year Purchased
ASV Hull Form/Platform	Lowes/SD Mines	N/a	48” × 32” × 10”	Custom	$71.92	2022
Waterproof Connectors	N/a	N/a	Waterproof motors with silicon to protect box	Purchased	N/a	2022
Propulsion	BlueRobotics	T200 Thruster	7-20 Volts Operating FWD/REV Thrust at 20V: 14.8/11.1 lbf	Purchased	$358.00	2022
Power System	C.R. Fischer	SCP1255 0 G22 Battery	Chemistry: Sealed Lead Acid Voltage: 12 Dimensions (in): 9.41” x 5.20” x 8.07” Terminals: M6 Weight (lbs): 33.7 lbs	Purchased	$0.00	2022
Motor Controls	BlueRobotics	Basic ESC	Voltage: 7-26V Weight: 0.036 lbs Signal Voltage: 3.3-5 V	Purchased	$72.00	2022
CPU	Raspberry Pi	Pi 3	N/a	Purchased	$0.00	2022
Tele-operation	Spectrum		N/a	Purchased	N/a	2022
Compass	N/a	N/a	N/a	N/a	N/a	N/a
Inertial Measurement Unit (IMU)	N/a	N/a	N/a	N/a	N/a	N/a
Doppler Velocity Logger (DVL)	N/a	N/a	N/a	N/a	N/a	N/a
Camera(s)	Amazon	Arducam Mini	Sensor: IMX477 Resolution: 4056(H) x 3040(V) 12.3MP Frame Rate: 1920×1080@60fps; 4032×3040@30fps	Purchased	$130.00	2022
Hydrophones	N/a	N/a	N/a	N/a	N/a	N/a
Algorithms	N/a	N/a	Custom	N/a	N/a	N/a
Vision	NVIDIA	Jetson Nano	2GB 8.1 Oz ARM Solid State	Purchased	$145.45	2022
Localization and Mapping	Robtis.us	360 Laser Distance Sensor LDS-01	Voltage: 5V DC Detection distance: 120mm 3,500mm	Purchased	$196.10	2022 height