Technical Design Report : RoboBoat 2019

Military Technical College : MW Team

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***Abstract*— This report will provide an overview of how the team handled the challenges for the 2019 AUVSI RoboBoat competition. Competition strategy highlights the approach that was utilized to achieve the team's objectives. experimental results show how ideas were tested and developed into the current implemented equipment. 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.**

Keywords—Autonomous, LIDAR, GUI, ROS

I. INTRODUCTION

The RoboBoat Competition is an annual autonomous vehicle competition in which student teams design and build fully autonomous boats to compete against teams from around the world. This year's competition is held at June 17-23 Daytona Beach, Florida, and It will be our first time in attendance. This paper details Suez's design process, including the teams' objectives, challenges, and design decisions for each part of the boat: hulls, Quadcopter, propulsion system, hardware, and software.

II. COMPETITION STRATEGY

A. *Hull Design:*

We based our design solely upon our aims and the best percentage achieved from each of our goals which are:

- Minimum weight.
- Minimum drag.
- High stability.
- High maneuverability.
- Enough safety factor for buoyancy and design strength.

So to minimize our weight yet have a strong structure, we made our vessel from various materials each in its best application to give us the highest strength and the lowest weight. We used PVC pipes for structure bones, we used polyuria as a coating for water isolation and obtain desired surface finish for lower drag and we used low density foam to generate our hulls form.

For minimum drag, we based our hull's design on the NPL series for high speed vessels and we customized it to provide us with enough buoyancy within our dimension limit, it still retains a low drag profile compared to our previous designs.

For production method we choose to split our boat into sections and make wood sections as a guide for our curve then we aligned the section and collect it to maintain our shape as shown in Fig. 1, Fig. 2 and Fig. 3.

Fig. 1. Foam-Wood sections

Fig. 2. Boat sections assembly

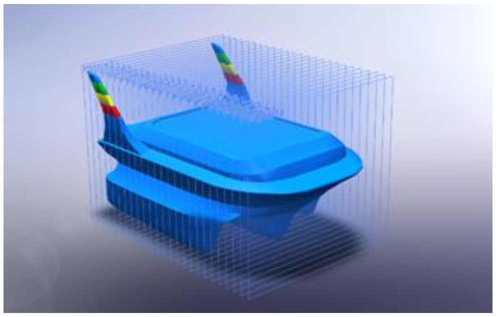

Fig. 3. Boat software assembly

B. *Quadcopter:*

Our Quadcopter is made out of more than 12 parts connected together using snap fits as shown in Fig. 4, each part is made with ABS filament using najoua 3d printer, we also used Dualsky ECO 2814C Motor with 1060*3 propellers – Raspberry Pi 3 – 3300 MAH LiPo battery – px4 flow – kore carrier board with cube – GoPro Hero4 session.

Fig. 4. Quadcopter design

C. *Object Detection and Recognition:*

In order to get the boat to move among the buoys without hitting them, we need a system to locate them, generate a map and navigate through it, so we used LIDAR and Stereovision camera. To make sure our boat recognizes the obstacle in front of it, a camera will also be present for differentiating between buoys by both shape and color.

D. *Positioning:*

We made a positioning system in order to localize the position of the boat relative to the obstacles which collects data from several sensors and combines them to get results as accurate as possible so we placed GPS, IMU and Compass on our boat so once the computer on it have its location and the waypoint, It will give the thrusters enough power to move the boat to its destination using differential thrust.

E. *Mission Tasks:*

1) *Autonomous Navigation:*

From the starting GPS coordinate, our boat will look for the nearest gate and once our boat finds it, it should move through it to a point at a specific distance then it should start locating the end gate then pass through it and get to the next task.

2) *Speed Challenge:*

Detection and color classification were chosen to position the vehicle and start the challenge. The vision system was used to detect the red and green buoys and pass between them with maximum velocity and also detect the orange tower and circle around it, and exit through the same buoys.

3) *Find the Path:*

In order to generate a path through the buoys, the boat will start looking for the white can buoy in the center of the buoys using its camera. Once detected and located, the boat will circle around the buoys and looking for the suitable gap then it generates a path to a point near this buoy. Once there the boat will circle around the white buoy and look for the nearest way out.

4) Automated Docking:

The boat shall get in front of the center of the docks with a specific perpendicular distance and use a system of hydrophones to scan for the frequency of the acoustic signal and localize the source then the boat shall move to the dock producing that signal then undock from it and get to the next task.

5) Raise the Flag:

The boat will stop near the dock then the computer on the boat will send a signal to the quadcopter onboard to take off to a specific altitude then the camera on the quadcopter will take a picture of the seven segment on the dock and send it to the computer to analyze it. Once the computer recognizes the number in the seven segment it will send another signal with a GPS coordinate to the quadcopter to land on it then the boat will circle around the dock till it finds the recognized number then pushes the button below it then the flag is raised.

III. DESIGN CREATIVITY

A. *Mechanical Design*

Big part of our mechanical creativity lies in our production methods and since the competition evolves a lot of steering based tasks compared to high speed tasks, we made our design leaning to stability and maneuverability rather than high speed so we went along with a trimaran design for high stability and a vector (differential) propulsion system for tight turnings.

With our multi-material composed design, production processes to obtain maximum rigidness for foam, coated with polyuria yet weights almost 55 lbs. we have an ASV that can actually head into real life environments and with a 100 lbs. maximum buoyancy (in fresh water), high durance batteries and strong thrusters, shortly we made our own mini-battleship Suez as shown in Fig. 5.

Fig. 5. Suez Battleship

B. *Software*

LabVIEW has been used due to its simplicity and creativity to design our own GUI.

The developed ROS code has been integrated LabVIEW by only send command velocity to the controller, we kept it simple and stupid. Our design is modular & easy to understand.

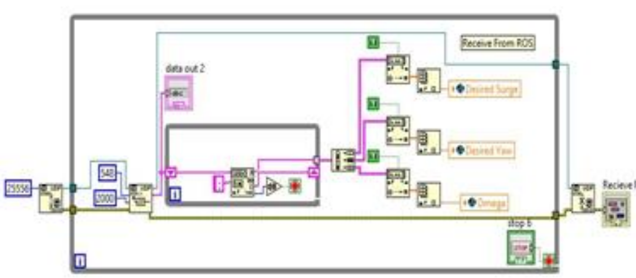

Fig. 6. Navigation

We used MyRio as it helps us to make our code run real-time and it is compatible with LabVIEW in addition to that its response is very fast compared to other microcontrollers. We used ROS to send command velocity to MyRio as shown in Fig. 6; hence, the PWM comes out to the thrusters.

We used a VI, as shown in Fig. 7, that solved our problem in PID control after we asked National Instrument for help. We used UDP communication between ROS & LabVIEW.

We used very accurate sensors to localize our boat on the simulation and make our simulation like the real one. Sensors such as VectorNav 200 and GPS Module.

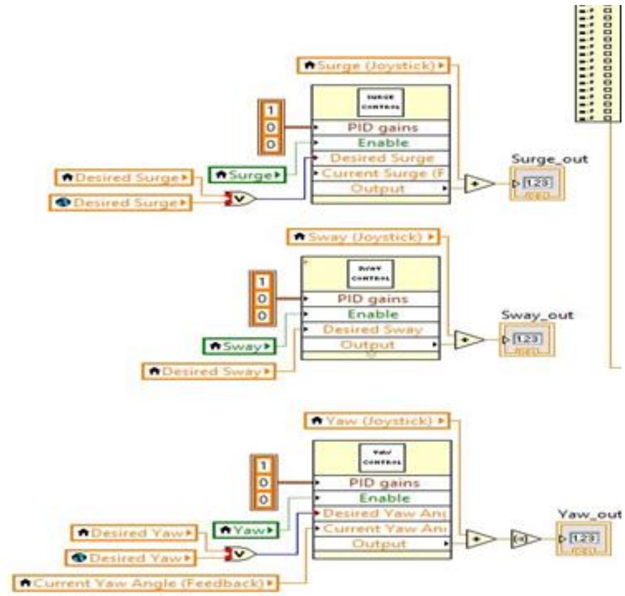

Fig. 7. PID control strategy

IV. Experimental Results

Body plan view for wave simulation with MAXSURF at maximum speed as shown in Fig. 8.

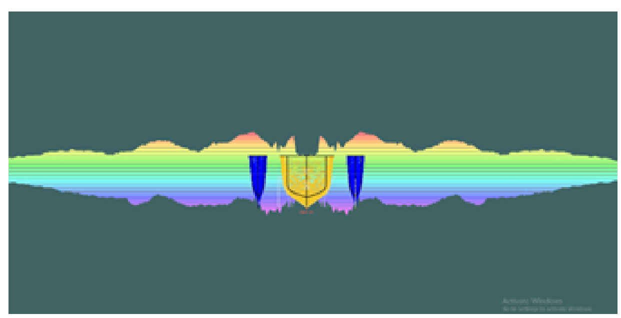

Fig. 8. Boat water line

Also, Perspective view for wave simulation with Maxsurf at maximum speed as shown in Fig. 9.

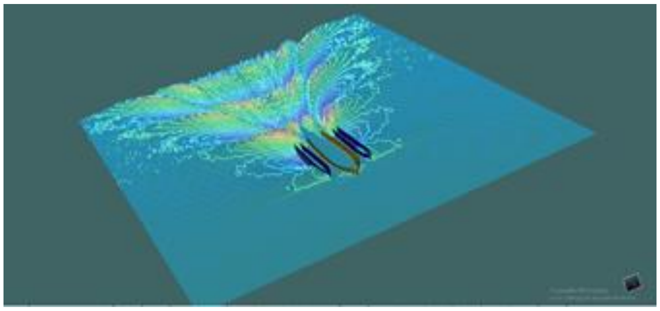

Fig. 9. Water resistance

In addition, testing of all autonomous tasks has been performed using Gazebo simulation as shown in Fig. 10.

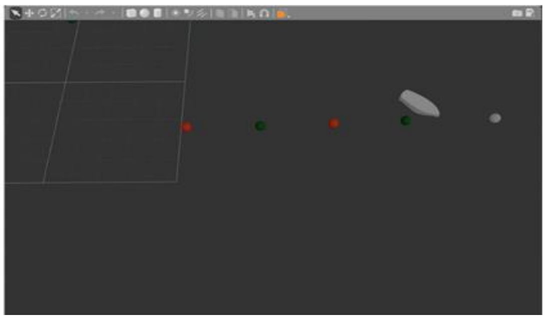

Fig. 10. Slalom maneuver simulation

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SPONSORSHIP

The MW team has a great sponsors that provide funding and equipment to the team through their generous contributions supporting us and our participation in this competition.

Fig. 11. Thank You to Our Generous Sponsors!

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APPENDIX A: COMPONENT SPECIFICATIONS

NO	Component	Vendor	Model/Type	Specification	Cost
1	**ASV Hull Form/Platform**		Trimaran		
2	**Propulsion (4 Motor)**	Blue robotics	T200 Thrusters	Each: Thrust 5.1 kgf and Power 350 watts	$ 1170.00
3	**Power System (16 Batteries)**	ev-power	LiFePO4	720Wh	$ 430.00
4	**Motor Control (microcontroller)**	National Instruments	Ni-MyRio	-	$ 535.00
5	**Computer (GCS)**	Amazon	-	Intel NUC NUC8i7BEH Mini PC	$ 850.00
6	**Computer(Boat)**	Amazon	Jetson Nano	-	$ 150.00
7	**Communication (Router)**	Amazon	TP-Link AC2300 Smart Wi-Fi	-	$ 240.00
8	**Stereo Vision**	Logitech	ZED 2K stereo camera	-	$ 1000.00
9	**LIDAR 360**	Robot shop	RPLIDAR A2M8 360° Laser Scanner	-	$ 300.00
10	**IMU**	Vector-nav	vn-100 kit	-	$ 800.00
11	**Hydrophone**	Aquarian audio	H2A HYDROPHONE	-	$ 170.00
12	**RC Transmiter and receivers**		Futaba 8JA	8-Channel 2.4GHz	$ 400.00
13	**Camera**	Amazon	Logitech c930e		$ 82.00
14	**GPS**	Amazon	Adafruit ultimate GPS breakout	6 channel W/10 HZ updates (ADA746)	$ 80.00