Roboboat 2023: technical design report

AASTMT HAPI team

Abstract- Hapi is a Roboboat team represent Arab Academy for since, technology and maritime transport. This technical design report (TDR) demonstrates the design of Autonomous Service Vehicle (ASV) was built to Roboboat 2023 and the compotation strategy. The ASV was design to fulfill the goals and pass all the tasks in the competition. The ASV had each component are separately tested throughout simulation software, ground test or water test.

Keywords - catamaran, AI, ASV.

I. Competition strategy

a. Navigate the Panama Canal

The navigation channel represents a crucial aspect of this mission as it showcases the fundamental autonomous control and sensing capabilities of the boat. To steer the boat's movement, two sets of red and green buoys were utilized as waypoints. The boat was equipped with a camera that aided in reaching each gate and avoiding obstacles through the use of depth calculations. To streamline this process, we opted to utilize the waypoint following feature of the Pixhawk PX4 flight controller. This feature allows us to transmit local pose set points to the boat, simplifying the control system. By utilizing our waypoint system, we simply need to generate midpoints of the pairs of buoys to form a series of waypoints, and the Pixhawk flight controller will automatically manage the actuators to bring the boat to the desired pose. as shows in figure 1which is the first

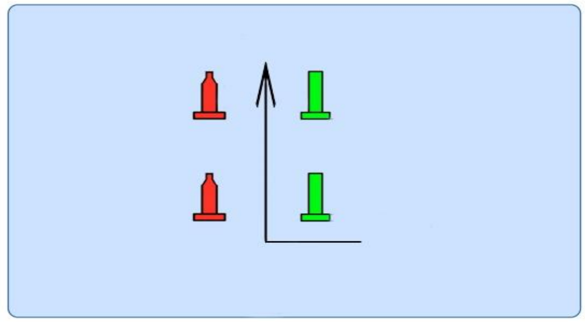

Figure 1 navigation Panama Canal task.

b. Magellan's Route

The vessel carrying out 2nd task, this mission demonstrated its proficiency in navigating through an intricate route while remaining within the designated path and sidestepping any obstacles encountered along the way. The ZED depth camera readings served as the primary source of guidance for the ship, allowing it to follow the green and red buoys while circumventing the yellow and black buoys that acted as obstacles. The navigation system was vital in defining the beginning and end of the course, while the depth information obtained from the camera was used to prevent potential hindrances. Figure 2 presents Magellan's Route / Count the Manatees & Jellyfish task.

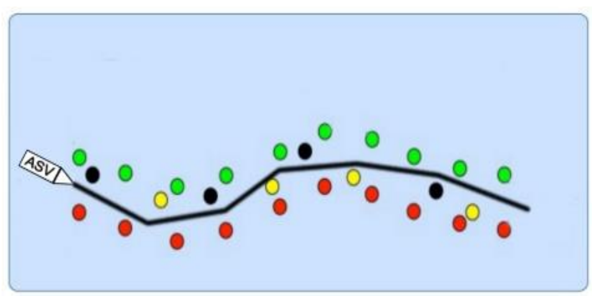

Figure 2 Magellan's route task

c. Northern Passage Challenge

The 3rd task, the boat has been assigned the challenge of circumnavigating an obstacle by utilizing its navigation system in conjunction with the camera, which functions as its primary sensing device. The boat must scan the pair of red and green buoys, pass through the gate, detect the blue buoy, execute a U-turn, and then re-enter the same gate via the red and green buoys. The entire duration of the challenge requires the boat to rely on its navigation and camera capabilities to successfully complete the mission and reach its destination. Figure 3 show the pass of ASV to implement the task.

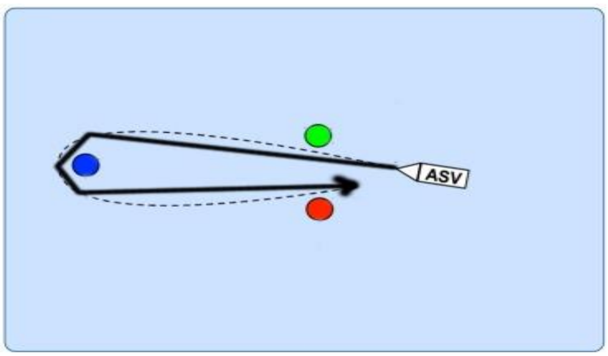

Figure 3 Northern Passage Challenge

d. Feed the Fish

The purpose of this challenge was to evaluate the capability of our boat to interact with its surroundings. The boat was equipped with a purple frame, which enabled it to locate the feeding table with three holes that dispensed racquetballs. To enhance the boat's performance, we devised a 2-degree-of-freedom (DOF) shooter, which allowed us to independently regulate the horizontal and vertical launch trajectory without moving the boat. To achieve this, we attached the entire shooting system to a rotary platform, enabling the boat to aim at the x and y planes. Additionally, we designed the launcher to fire through a tube that can rotate vertically for better control on the z-axis.

e. Ponce de Leon

Our approach was to shoot as much water as feasible to enhance the chances of hitting the target and reduce the filling time of the tube to raise the ball above the green line. We determined the optimal GPM to be 0.82, respectively, based on the launch distance and required water volume. To ensure safety, we ultimately selected a pump with a flow rate of 18.3 GPM. Similar to the skeeball mechanism, we aimed to have independent control of the water gun without affecting the stability of the boat. This was achieved by connecting the pump output to a platform that can rotate in two axes and controlling the pump's power to adjust the z-axis height.

II. Creative design

1- Naval

- Hull design

In more details comparison between mono hull or more than hulls, we decided to choice the catamaran design due to: We selected the catamaran design to minimize frication and reducing power requirements. due to its stability, speed, and versatility. The two hulls provide a stable platform that can handle rough seas, while the shallow draft allows for easy maneuvering in shallow waters and more light in weight. the ASV was built using Fiber Glass is a type of fiber-reinforced plastic that is widely used in small boats due to durability, low maintenance, easy in fabrication, lightweight and less cost if compare with carbon fiber. By using MAXsurf to design the catamaran boat by specification presented in table 1 and calculate the powering in sailing darft. Figure 4 demonstrate design file by using Rhino software.

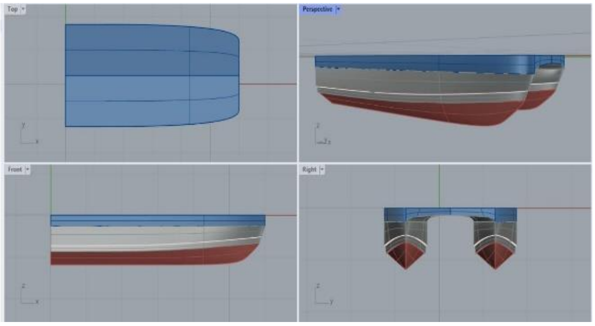

Figure 4 Rhino file export

Table 1 ASV specification

Items	Value
Overall length	5.9 ft
Beam	2.9 ft
Depth	1.19 ft
Draft	0.21 ft
Pollard pull	7.96 Ib
Max speed	4.86 Knots

- Propulsion system

We used one Blue Robotics T200 Thrusters at each hull's stern. The T200 thruster is attached to the hull by bracket designed by using solid works then printed in plastic 3D printer. Figure 5 present T-200 thruster fixation to hulls. Any three-phase brushless motor, such as the thrusters and motors from Blue Robotics, need an electronic speed controller (ESC) to operate. The T200 thruster can run on this 30-amp ESC.

Figure 5 T-200 fixed in hulls

2- Mechanical

In this section illustrate the mechanical system which take place in the ASV.

- Hull fabrication

In order to build a body for the ASV using durable and strong material such as fiberglass we had to follow chain of steps and operation to reach the required results considering time and resources. after finishing the final design for the vessel hull we had to construct a mold.
The mold was consisted of several sections using light materials such as Mdf wood cut off by CNC router machine. Then, placed parallel with equal interval spaces and connect together by strong wood kill, as shown in figure 6. Finally, covered by thin plywood to form the vessel smooth hull, as presented in figure 7. after finishing painting the wooden mold in order to gain smooth surface for the next operation fiberglass construction.

Figure 6 hull interval spaces

Figure 7 covered the hull

- Water & Air shooter design

for the water and air gun. we designed a mechanism drawn by solidworks, as shows in figure 8. The mechanism moves in angular motion and vertical motion controlled by two servo motors for both guns fixed vertically together to aim on the target. and by that we are able to aim at any target in 180 degrees ahead using only the cameras detection.

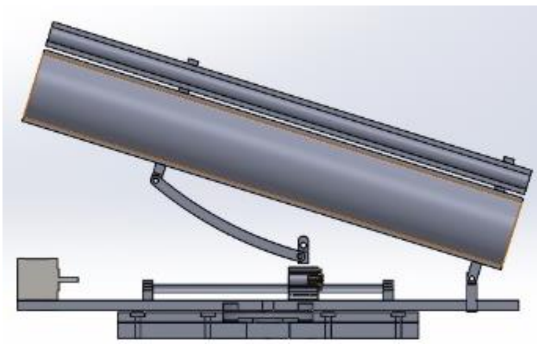

Figure 8 double shooter design

- Pump selection

As for water gun we selected a pump. one must deliver the required purpose with low power consumption and lightweight so we used bilge pump 1100 GPH. Figure 9 shows the bilge pump and table 2 present pump specifications.

Figure 9 bilge pump.

Table 2 Pump specification

Items	Value
Voltage	12Vdc operation
Flowrate	11000 GPH/18.3 GPm
current	3Amp motor
Discharge line dimension	29 mm/ 1-1/8″barbed outlet
Pressure Head	4 meters / 13.1234 feet

- Thruster bracket

To fix two T200 to every hull we designed motor brackets drawn by solidworks made from 3d printed plastic which is light material designed to reduce friction and drag and easy in assembly. Figure 10 shows the bracket design.

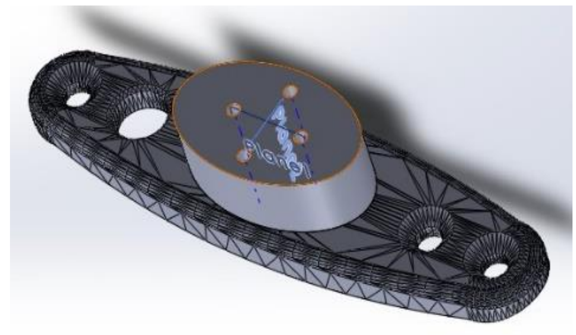

Figure 10 bracket design.

3- Electronics

The electronics group prepare interface between Artificial intelligent system and mechanical, prolusion, maneuvering systems. We encountered various issues in the control and power distribution systems when implementing our power and controlling systems, and in order to fix these issues, we used CAD to construct PCBs, some of which are described below.

- Power protection

The first board is a diode protection board; whose major role is to prevent back induced emf from inductive loads like the used motor T-200. To overcome this problem, we simply used a diode, which allows current to flow in only one direction, so we began by calculating the draw current of the used motor in order to pick the appropriate diodes, and then we began to design a schematic for the PCB and Designing the PCB. Figure11 shows Diode protection PCB 3D Model and figure 12 shows Diode Protection PCB Schematic

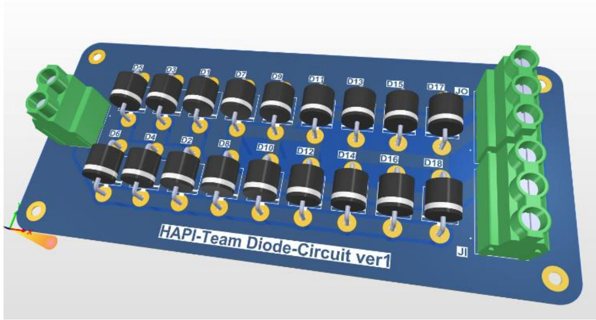

Figure 11 Diode Protection PCB 3D Model

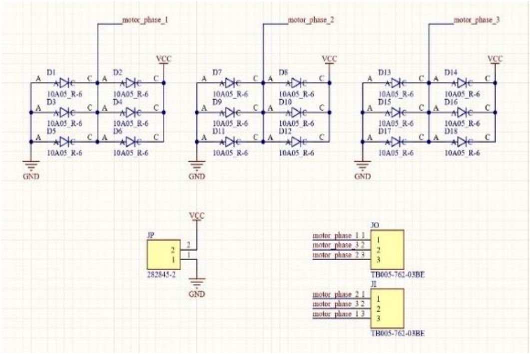

Figure 12 Diode Protection PCB Schematic

- Control system

The second board it was a signal inverted board, In RC control we have faced problem with receiving serial data from receiver module in which the data we are receiving it was inverted. In order to solve this problem, we have made a PCB design in which it reverse the input signal from the UART SBUS in receiver module. Figure 13 shows Signal inverted Board 3D-Model and figure 14 present Signal inverted Board Schematic

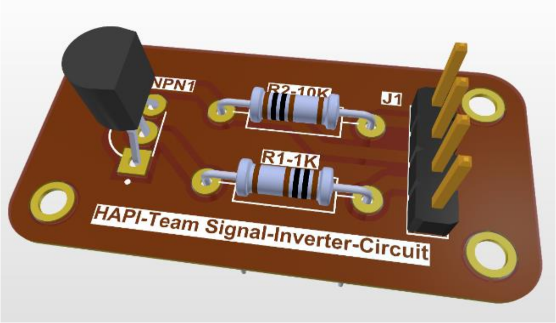

Figure 13 Signal inverted Board 3D-Model

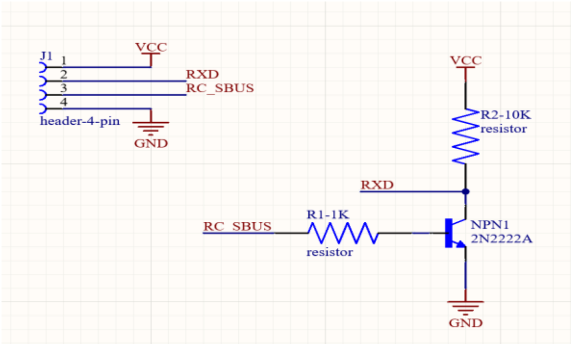

Figure 14 Signal inverted Board Schematic

4- Artificial Intelligent

a. Navigation System

The navigation system is an integral component of a ship that provides guidance and direction during its mission operations. It utilizes advanced technology such as the Pixhawk PX4 flight controller and the mission planner software to establish predetermined waypoints for the vessel. The Pixhawk PX4, equipped with a highly accurate GPS module, enables the ship to maintain a precise positional accuracy of within one meter, ensuring efficient and effective navigation. Sensor System (Camera).

The sensor system on board the ship is comprised of a ZED 2i depth camera. The sensor system is triggered automatically when a detection event is detected. The inputs for the sensor system are received from the Pixhawk navigation system, based on camera readings. The ZED 2i camera is used to detect and identify navigational aids such as gates and buoys by classifying them based on shape and color. To ensure safe navigation and prevent collisions with obstacles, the camera calculates the depth of detected objects. The ship employs various algorithms to determine the appropriate maneuver based on the conditions of the mission. The ZED 2i camera functions as the primary sensor, regulating the ship's movements, and its results are processed by

Jetson and transmitted to the Arduino system to control the motors.

III. Tests and experimental

In this section present the result of marine tests and experimental done on hull in swimming pool.

- Stability

In stability test the ASV sailing in no added weight found that draft is 0.21 ft and the boat is even kill. Then added 55 Ib weight found that the draft is 0.41ft and the boat is even kill also. Figure shows the no inclination in both of transverse or longitudinal axis. Figure 15 shows the stability hull test.

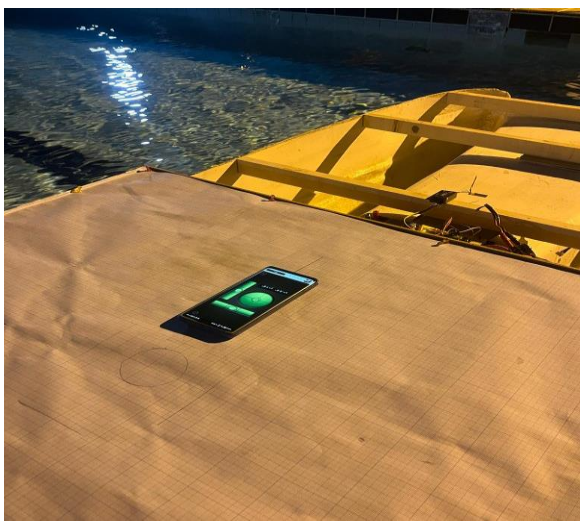

Figure 15 stability hull test

- Pollard pull

In this test examined the force of pull occurred in the ASV when move ahead in full speed. the test steps are connecting the digital scale in boat stern, then move the ASV in full speed in forward direction and measure the value of pull which recorded in the scale. The value which recorded in the scale is 7.96 Ib as shows in figure 16.

Figure 16 pull test.

- Speed

In this test calculate the average speed of ASV at sailing draft 0.21 ft and when the boat reach to steady state speed. the boat takes the 98.4 ft in 12 second, so the average speed is 4.86 knots.

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