Technical Design Report Roboboat 2022
Military Technical College - MW

Abstract—**MTC is ready to conquer the RoboBoat competition with a really bright-minded team. The team contains three groups: Mechanical, Electrical and Multimedia. The team confronted some challenges with the old version of the boat to adapt with the new competition strategies. The boat has also undergone a redesign, reducing its weight, increasing its hydrodynamics and maintaining it stable catamaran design. The competition strategies revealed within this report discussed the design process in a brief way, imposing several specific requirements on the vehicle design and construction. This includes the presence of various sensor used efficiently to provide the boat with the ability to do the tasks smoothly. Also, the team encountered many creative decision-making of the engineering team for mechanical and electrical trade-offs studies regarding the robot design.**

I. Introduction

MW team started off as a project-group at Military Technical College (MTC) for Roboboat competition 2022 entry. This is the 2nd time that a team from the MTC will participate in the Roboboat Competition. Progress of the school year and subsequent graduation of several senior members, caused some changes in team management. Improvements and redesign of some sub-systems of the vehicle was deemed necessary, as robustness in the previous participate was not guaranteed and to adopt with the new competition tasks. Overall it has been a very exciting process and this report will provide an overview of how the team handled the challenges.

II. Competition Strategy

Our team approaches the competition tasks with minimum effort, time and cost to collect as many points as possible. Due to the changes in the tasks this year, the team decided to make some decisions that traded-off some features to adapt to some tasks. In this section we will provide insight into how the team planned to do this. Initially, the subsystems used in the challenges will be presented, followed by a short explanation of how each challenge will be accomplished.

A. Navigation Channel

Being a main mandatory task, we gave it the highest priority. It is required that the ASV navigate through two pairs of red and green buoys in a fully autonomous manner. The two buoys are at least 6 feet apart. The two sets of buoys are at least 50 feet apart. We decided to complete this task with image processing by color detection without the need detection of shape. The camera was placed in the most suitable location that suits all requirements of the upcoming tasks. We made an algorithm that guides ASV and maintains a suitable distance between the red and green buoys according to camera detection. The algorithm instructs the ASV to maintain the initial direction in seek of the exit gate. As soon as ASV passes through the exit gate, it proceeds to the next task.

B. Avoid The Crowds

The ASV is required to sense and maneuver between multiple sets of gates consisting of pairs of red and green buoys. The ASV must not touch the buoys and avoids intermittent yellow buoys in the pathway. This task depends heavily on the camera, putting an extreme processing load on the NUC. So we decided not to use the LIDAR to reduce the complexity of this task. As ASV pushes forward, it must localize itself between the two buoys, putting the green buoy on its right, and the red buoys on its left using right or left thrusters independently. If a yellow buoy is detected, the distance between it and each buoy is calculated and the ASV is directed towards the largest distance to maintain a smooth path.

C. Find a Seat at the Show

Despite being a straightforward task, it took a lot of effort by our team to perform it. We decided to use both LIDAR and a camera during this task so we constructed an extremely complex algorithm, which eventually managed to pass the task successfully. The camera is used to detect the shape and color of the window. According to the result, the boat starts to adjust itself to park on the dock. The LIDAR measures the distance between the boat and dock to inform the boat with the accurate distance to find a seat.

D. Snack Run

This challenge will be completed in a manner very similar to the Navigation Channel task, then ASV had to find the blue buoy rather than the second gate. As soon as ASV passes the first pair of buoys, it pushes forward with a full thrust with the same heading until the blue buoy is detected by the camera. ASV moves toward the buoy, reducing its speed gradually until it is at a suitable distance measured by the LIDAR. It then circumnavigates the blue buoy, and moves again toward the entrance gate with full thrust, completing this task as fast as possible.

E. Skeeball Game

Being a new task, we perform some modifications to the boat mechanical design, we added a gun to hold and shoot the balls via the water jet. As a trade-off, we decided to make the water jet fixed instead of using servomotors this method would benefit in decreasing the complexity and weight of ASV. ASV detects the frame and then holds a position at a suitable distance from it, using trial-and-error then deploys balls through the frame and onto the Skeeball table, in any of the three holes.

F. Water Blast

Using the same water jet mechanism used in the previous task, water is delivered through the center of the target, after its detection using a camera and a suitable distance from the dock is maintained using trial-and-error. Water is pumped from the surrounding environment instead of storing it onboard to decrease weight and increase stability

III. Design Creativity

A. Hull Design

From a mechanical perspective. We decided to go with a double hull design as it grants increased stability than a single hull design. However, it increases resistance in water [3] thus decreasing the ASV speed in water which is an acceptable trade-off due to competition tasks containing a lot of steering-based tasks compared to high-speed tasks as shown in Fig. 1.

Another trade-off was that we increased buoyancy, the maximum load onboard of the ASV thus increased correspondingly. Thus increases the overall weight. As a countermeasure, we replaced last year batteries with lighter batteries, and instead of using a traditional circuit, a custom-made PCB was used to decrease weight.

Fig. 1. Manufacturing process

B. Cooling System & PCB

A PCB was designed to replace internal wiring system to reduce complexity and weight of the ASV and make it easier to maintain as shown in Fig. 3. A new design for the cover was essential to counter our weak points in the previous design where we noticed that performance was degraded due to rise in NUC's temperature. The cover provides enough space for the internal components with calculated spacing for each individual component to prevent any interferences between them and allow for the air to flow releasing the heat accumulated from the NUC and the PCB where the air enters through the upper back of the cover and is exhausted through the sides making sure the is no water particles may enter as shown in Fig. 2.

The new fiberglass cover design improves aerodynamic and generates less drag force upon movement and is both lighter and smaller than the previous wood cover design [4].

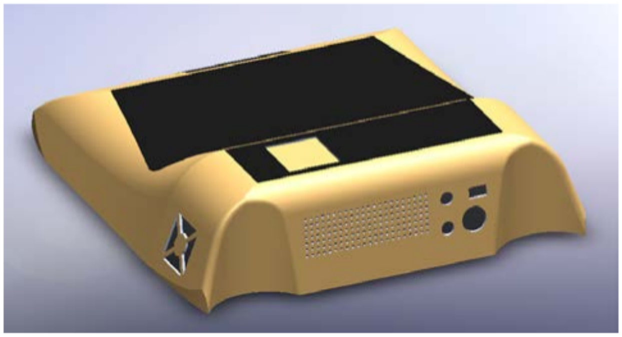

Fig. 2. Cooling system and charging interface

We also used silica gel to absorb humidity in the air from the surrounding environment. The new cover also provides an interface for charging the battery and showing its status externally through an LCD so the cover needn't be removed.

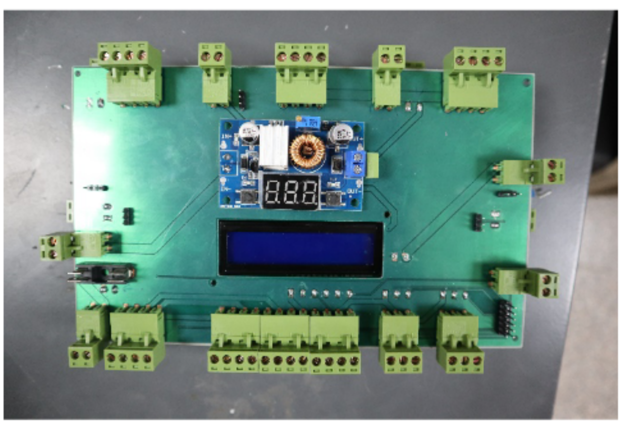

Fig. 3. PCB

C. Navigation system

We integrated the IMU and GPS to move from one point to another using the Kalman filter.

We encountered many issues with the GPS module due to local restrictions but we managed to solve them.

ASV heads towards the next waypoint with aid of IMU and GPS module rotating in a closer direction, then as LIDAR detects any nearby obstacle, it uses a special algorithm to avoid it.

D. Software

We used LabVIEW for control due to its simplicity & creativity.

We integrated our ROS work with LabVIEW by sending only command velocity to the controller, we have tried to keep it as simple as possible. Our design is modular & easy to modify as shown in Fig. 4.

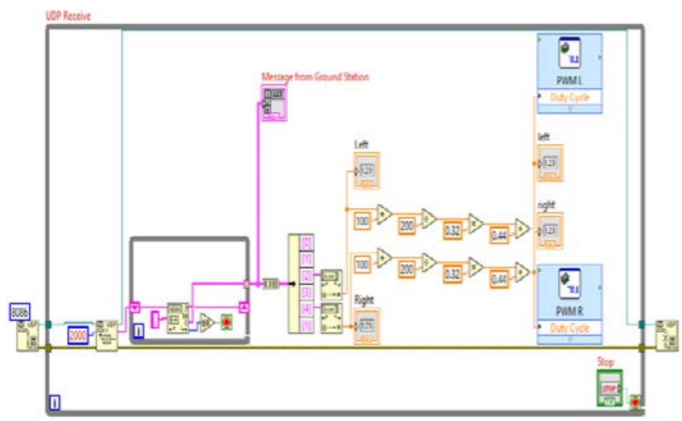

Fig. 4. Communication between ROS & LabVIEW

In addition, we used MyRio as the controller, where it's compatible with LabVIEW in addition to its quick response compared to other microcontrollers. We used ROS to send command velocity to MyRio. Hence, it sends PWM signals out to the thrusters.

IV. *Experimental* Results

As mentioned before, a double hull structure (catamaran) was implemented to achieve higher stability and a decent buoyancy, Results from Maxsurf stability and experimental testing in water as show in Fig. 5 gave us satisfying results which encouraged us to use this design model. Furthermore, manufacturing Fiberglass boat improved buoyancy where the overall weight decreased which increased speed and waterboard.

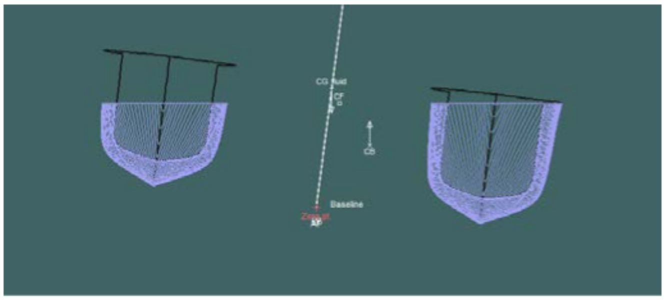

Fig. 5. CFD analysis of Vehicle’s stability.

The hull design used was taken from many experiments using Maxsurf as shown in Fig. 6, where we picked the best volume to drag ratio, so it provided high enough buoyant force and good speed in the water as water resistance was highly taken into consideration.

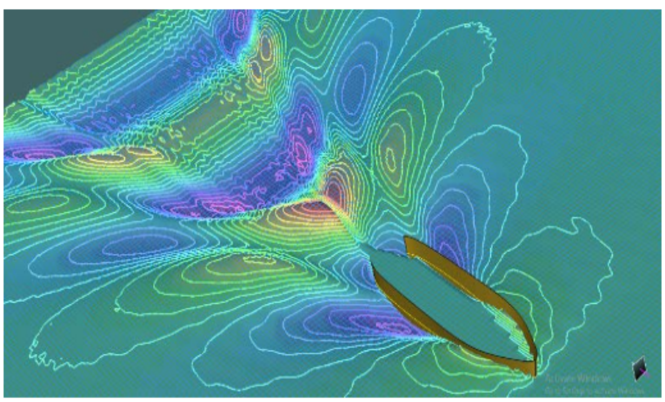

Fig. 6. CFD analysis of boat resistance.

V. Acknowledgment

The Idea of creating the team and make it able to participate in this competition wouldn’t have become a fact without all generous contributions and support of our college Administrations, Staff members and supervisors of the team.
It helped us by providing funds and necessary equipment to the team, so they are one of the main reasons for what we have reached so far.

UMIS-TIC

Thank you for your support

VI. References

[1] Robonation, Rules and tasks Descriptions version 1.

[2] Robonation, RoboBoat 2022 Scoresheet.

[3] T. I. Fossen, Handbook of marine craft hydrodynamics and motion control. John Wiley & Sons, 2011.

[4] J. Randolph Paulling, Book of The Principles of Naval Architecture Series, 2010.