National Taiwan University WAM-V Application

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A. Technical Approach and Justification

We are the team from Underwater Acoustic Laboratory, National Taiwan University. The lab was only-specializing in underwater acoustic before. In recent years, we are implementing the autonomous detecting method which is getting more popular so our lab has started to develop the autonomous vehicle to help us collect acoustic data. Prof. Chi-Fang Chen has worked with LAMSS lab in MIT since 2016 and the purpose is to acquire the technology of MOOS-IvP middleware (a middleware for marine robotics) back to Taiwan.

What we have done by using MOOS-IvP were measuring the underwater ambient noise and the marine mammal whistle detection (see Fig. 1). Once the waypoints were set, the Unmanned Surface Vehicle (USV) will measure the sound pressure level (SPL), sound exposure level (SEL), and whistle detection along with the waypoints. The whole platform can save lots of money and manpower.

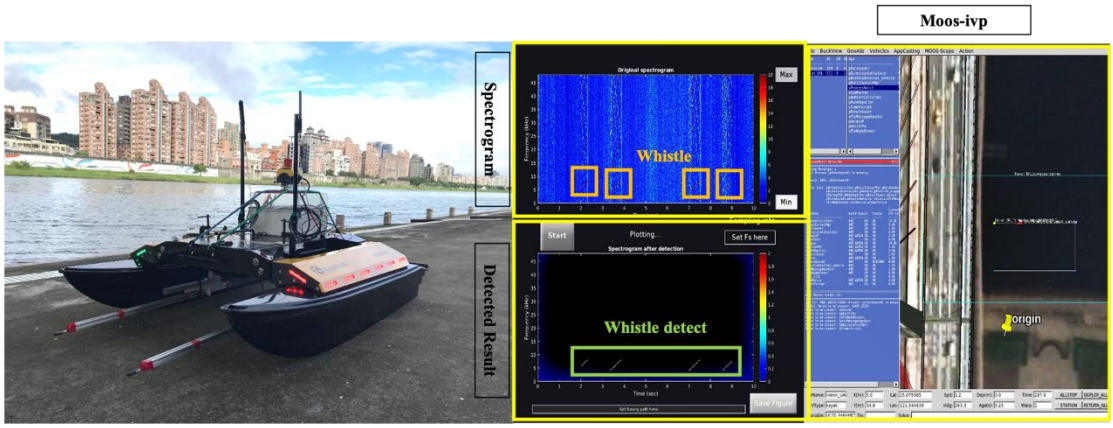

Fig. 1 USV and MOOS-IvP

The NCTU team invite our lab to join their team to participate in 2018 RobotX competition. And we were in charge of the “Entrance and Exit Gates” task. The NCTU team got fifth place eventually. In 2019, our lab participated in 2019 VRX competition as tang team and got sixth place.

From the competition experiences we have learned, we summarize the following challenging issues and challenges that need to be overcome:

1. If the current is strong, WAM-V is hard to do the station keeping and face the target to scan the symbol or the shape.

2. The steering power was not strong enough with only two rear thrusters. The response time is too long for changing the direction to get the controlling result that we expected to.
3. The wi-fi communication between WAM-V and the shoreside was unstable. We controlled the WAM-V via wi-fi in 2018 RobotX so it might lose control when the WAM-V loses the connection.

In 2022 RobotX, we are planning to utilize the following techniques to achieve the task goal:

1. The software part: Combing **MOOS-IvP** and **Robot Operation System** (ROS) to control the WAM-V, MOOS-IvP will be responsible for waypoint designing and being the brain of WAM-V, and ROS will be responsible for receiving the data from sensors and controlling the thrusters. After doing the data preprocessing, ROS will send the messages to MOOS-IvP to make the final decision.
2. To increase the flexibility of WAM-V, four thrusters will be attached to WAM-V, two for controlling back and forth, two for turning left and right.
3. DRGB cameras will be used for visual recognition and rough object localization; the LiDAR will be used for building up an object map. We can use the data acquired from the cameras to label the objects on the object map to decide the best path and avoid the obstacles.
4. Unmanned Aerial Vehicle (UAV) and WAM-V will connect to each other by wi-fi. UAV can get the position of WAM-V and land on WAM-V. DRGB camera will also be installed on UAV to identify the buoys.
5. There will be a hydrophones array system to hear the sound from the beacon. By calculating the steering angle, WAM-V will know the location of the active beacon and pass through the gate. This technique had been used in 2018 RobotX.
6. A Radio controller will be used to control the WAM-V. It can switch the control methods anytime.

B. Team Qualifications

1. All of our team members have learned a series of classes to write the code for marine autonomy with MOOS-IvP middleware. And all of our team members have basic knowledge of ROS.
2. Some of our members are capable of dealing with the image and point-cloud data from visual camera and LiDAR. After processing those data, we can identify the trained object and avoid the collision.
3. Some of our members master in ocean acoustics, which would help us get through task 1. As we mentioned before, we can not only measure the ambient noise, but also know where the marine mammal whistle comes from.

4. Most of our members are master students in engineering. The Ph.D. student is our team captain who has several publish about the autonomous vehicle. A few members had joined the 2018 RobotX and 2019 Virtual RobotX.

C. Facilities

1. The Laboratory owns two Velodyne LiDAR and three Zed bio cameras. That equipment will do significant object detection and recognition. After the embedded computer receives the data from those devices, we'll process those data via Cuda OpenCV and do the information fusion so that we can tag the objects we've known and sent that information back via ROS to the main onboard computer.
2. We have high accuracy IMU and GPS, with those devices, and after combining, filtering those data via Kalman Filter, we are able to know the attitude, heading, and body motion of the vehicle.
3. The Laboratory operates the acoustic sensing payload for the vehicle. With three hydrophones onboard for detecting the direction of the ping.
4. The drone with an open-source module and camera will cooperate with the surface vehicle. Our lab used to train the dolphin images by YOLOv4 to detect the dolphins on the water; this technique will also be implemented in our drone to detect the wildlife and path planning in the RobotX tasks.

D. Sponsorships and Partnerships

Event	Year	Sponsor	Principle
Autonomous Ocean Sensing Workshop	2017	OceanSound CO.,LTD oceansound2016@gmail.com +886-2-23651211	Chiao-Ming Peng
Exchange Student Scholarship to LAMSS, MIT (student : Huang, Yen-Hsiang)	2018	OceanSound CO.,LTD oceansound2016@gmail.com +886-2-23651211	Chiao-Ming Peng
Exchange Student Scholarship to LAMSS, MIT (student : Chien, Ting-Yuan)	2020	OceanSound CO.,LTD oceansound2016@gmail.com +886-2-23651211	Chiao-Ming Peng
2020 RobotX competition (returning the fund caused of the competition was cancelled)	2020	Lungteh Shipbuilding CO. LTD sheldon@lungteh.com +886-2-26571830	Sheldon Huang

E. Management Approach

There will be a team of 10-15 motivated students from NTU, including Ph.D., master and undergraduate students. Prof. Chen is the team leader; The Ph.D.

student is the team captain; some master students are the sub-team leader. To carry out the program successfully, the following steps will be implemented. First, each member needs to have the programming ability to join the team. Second, there will be team training for the automatic system, including MOOS-IvP and ROS. Third, team members will work separately and distributed into different sub-team for different subjects such as sensors, image processing and power system etc.

Fig. 2 shows the rough timeline in 2022. After receiving WAM-V, our laboratory colleagues will start to do the preliminary planning of WAM-V and buy the things we don't have. Because Chinese New Year is from 2022/1/31 to 2022/2/7, finding the crew will be a little bit long that start at 2022/1/2 and end at 2022/3/17. ROS and MOOS-IvP training will start on 2022/3/18 and last a month. The members will be separated into different sub-team to work at 2022/4/19-2022/5/19; in the meantime, there will be a sub-team that is responsible for building the simulation word. From 2022/5/20 to 2022/6/31, we will test the solutions of tasks in the simulation word and fix the bugs. After the simulation test, the WAM-V will be moved to the water field to test the solutions from 2022/7/1 to 2022/9/30. The shipping time was expected one month, so we will remove the equipment on WAM-V and ship it from 2022/10/1 to 2022/10/7. The simulation test can keep doing during the shipping.

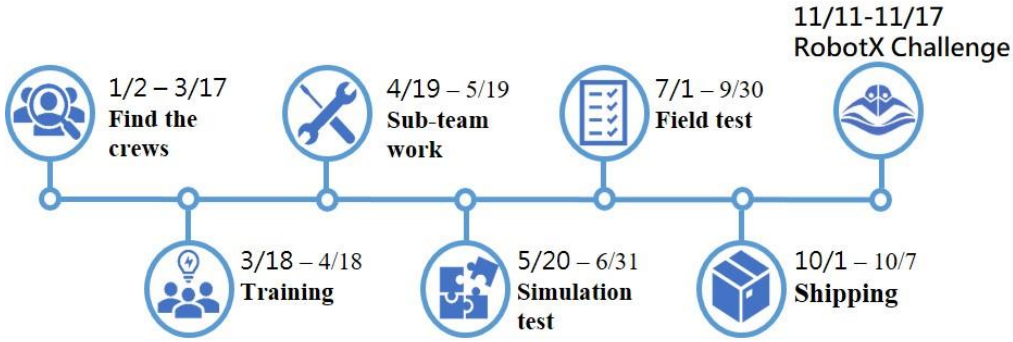

Fig. 2 2022 Rough timeline

F. Rough Order of Magnitude Cost

Equipment	Price (USD)	Account
Nvidia embedded computer	Already have	3
DRGB camera	Already have	3
Lidar	Already have	2
router	Already have	1
IMU	Already have	1
GPS	Already have	1
Hydrophone	Already have	3
Industrial Computer	2000	1

Thruster	4000	4
Drone	1000	1
12V lead-acid battery	100	several
Consumables	3000	1
Travel expenses	25000	
Ship fee	10000	

G. Summary

Although our lab is not a robot field lab, we have tried to use USV to do the measurement already and participated in the 2018 RobotX and 2019 VRX competitions. We got good scores in two competitions finally. According to the score and experience, we have the potential to do an excellent job in 2022 RobotX competition and feel confident to complete the tasks. Lungteh shipbuilding company and OceanSound company are our partners and will continuously support us in the competition, and also we can use the funding from the Ministry of Science and Technology, Taiwan. We believe that the crews from National Taiwan University, which is the best University in Taiwan, will give you an impressive performance in 2022 RobotX competition.