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1st Year of running MIR at UJI

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Abstract— The Universitat Jaume I de Castellón (UJI), in Spain, is one of the main partners of the Erasmus Mundus Joint Master’s Degree (EMJMD) in Marine and Maritime Intelligent Robotics (MIR). In this context, two different activities are under process for the current academic year (22/23) at UJI: the 2nd course (60 ECTS) for those MIR 1st Intake students having selected the study track “Applied Robotics for Underwater Intervention Missions”; and the Annual Symposium and Championship, organized by the UJI team (June 20-22). Thus, the aim of this paper is to give some practical details about the ongoing evolution of both activities, in order to benefit others from these experiences, and hopefully, gathering and showing useful ideas for the Marine Robotics Community at large.

Keywords— *higher education, artificial intelligence, marine robotics, underwater robotics, robotics competition, blue economy*

I. INTRODUCTION

The Erasmus Mundus Joint Master’s Degree (EMJMD) Program in Marine and Maritime Intelligent Robotics (MIR) (<http://www.master-mir.eu>) combines robotics and Artificial Intelligence (AI) to advance marine and maritime science and its technological applications. It aims at building the capacity to enable advances in far reaching sea exploration, autonomous deep-sea robots, teleoperations, and the use of AI in these endeavors. MIR debuted during the 2021/22 academic year at the University of Toulon (UTLN), where all students followed the common 1st year (60 ECTS, divided into two semesters). While the first year of the course takes place at UTLN, each student specializes in one of the three study tracks, encompassing a 3rd semester at one of the other main partners’ institutions (NTNU, Norway; IST-UL, Portugal; UJI, Spain). The MIR program fills a gap in the current EU education landscape by responding to a pressing demand for specialists in ocean technology [1]. It does so by building a consortium of actors around the globe with the common goal of advancing education and research in AI and robotics for ocean

applications. Further details concerning general aspects of MIR can be found in [2].

II. STUDY TRACK AT UJI

At UJI, in Spain, the MIR study track is entitled “Applied Robotics for Underwater Intervention Missions” and aims to endow underwater robots with the capability to interact with the environment using manipulators.

It is worth noting that to succeed with the teaching task in this context, the required strategic resources and know-how are available at UJI Campus. For better understanding the teaching design at UJI, in the following, some pros and cons, concerning the intervention vehicle's capabilities today, are considered [3]. So, while commercially available Autonomous Underwater Vehicles (AUVs) are routinely used in survey missions, a new set of applications exists which clearly demands intervention capabilities. The maintenance of permanent underwater observatories, submerged oil wells, cable sensor networks, pipes and the deployment and recovery of benthic stations are only a few examples of such applications. Nowadays, these tasks are mainly addressed by using manned submersibles or work-class ROVs (Remotely Operated Vehicles), equipped with teleoperated arms.

Current Intervention-AUVs (I-AUVs) prototypes are usually big and complex systems exhibiting only a limited set of functionalities including docking and fixed based manipulation on a subsea panel, as well as search and recovery of simple objects. Underlying the main drawbacks found in these kinds of systems are the current technology limitations in several domains including but not limited to wireless communications, human-robot interaction and simulation capabilities, multisensory based manipulation, networking, cooperative robots, or different control. Moreover, looking for increasing autonomy levels, cognition developments will also be a cornerstone, trying to replace dexterities associated with

the human expert on the intervention domain by means of Artificial Intelligence (AI) procedures. In summary, all these technologies will be the key contents assumed in this specialization.

The UJI subjects, with scientific-technological content, are: “Robotic Intelligence”; “Simulation, Middleware and Benchmarking”; “Wireless Communication”; “Cognitive Processes”; “Multi-robot Systems”; “Perception and Manipulation”; and “Telerobotics & HRI”.

Currently, at UJI, the students are working on their MSc Thesis (30 ECTS), after ending the 1st semester (30 ECTS, including eight different subjects). At the end of this Master, all Graduates receive a double diploma, from UJI and UTLN.

On the other hand, the main strategic resources will be the equipment and the infrastructure, including the necessary human resources. All these components are available at CIRTESU (Research Center for Robotics and Underwater Technologies), recently built in our Campus (https://www.youtube.com/watch?v=5te_SciX7Qs). This infrastructure (500 m²) has a water tank with a capacity of nearly half a million liters (See Fig. 1, bottom). Moreover, among different underwater robots available (e.g., BlueROV, SeaBotix ROV, etc.), there is a complete AUV for intervention, based on a GIRONA 500 AUV platform ([IQUA Robotics](http://IQUA.Robotics)) and a fully electric underwater robotic arm, of 6 DoF, (“REACH-BRAVO”), both equipped with a variety of sensors.

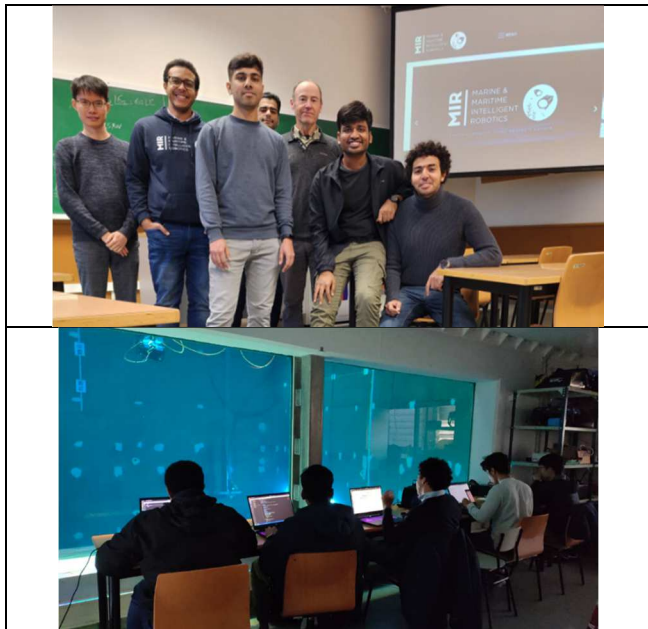


Fig. 1. Teaching in action during the MIR 3rd semester at UJI: “Lessons at Classroom” (Top); “CIRTESU hands-on activities” (Bottom).

In the following, some details concerning the specific subject “Telerobotics and HRI” and the guidelines for MIR’s annual symposium and competition at UJI are addressed. See Fig. 1, bottom, where students are learning to teleoperate the real BlueROV vehicle, in the water tank, by means of a GUI

module, developed by them. Some screens are showcased in Fig. 2 for this respect.

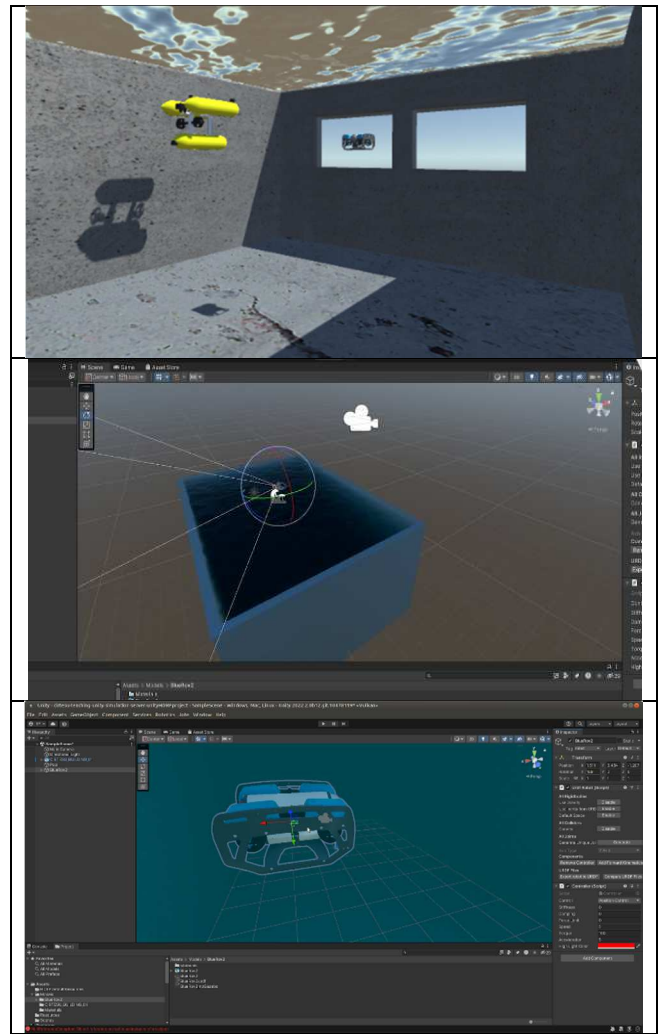


Fig. 2. Unity (game engine) used for: “creating scenes” (Top); “adjusting properties” (Middle); BlueROV Control (Bottom).

III. ANNUAL SYMPOSIUM AND MIR CHAMPIONSHIP

In the context of the joint MIR program, an annual symposium is hosted by a different main partner every year. It is worth noting that MIR students’ participation is compulsory in this “annual symposium and MIR championship”. The 1st edition was organized by UTLN (France, June 2022) and the 2nd one is under the responsibility of UJI (Spain, June 2023). The event includes, among others, the following activities,: a) International Marine Intelligent Robotics championship, open to industry and the public, b) Marine Intelligent Robotics academic and industry Conference, c) 1st year MIR student thesis proposal activities, d) 2nd year MIR student thesis results presentations, e) Management Committee (MC) physical meeting, f) Social events.

IV. MIR COMPETITION AT UJI

One of the key activities, organized by MIR in their symposium, is a robotic competition, the coming edition of

which will be held in June 2023 at UJI. The goal of the competition is for students to interact directly with the BlueROV platform and encourage them to develop autonomous inspection and navigation algorithms.

For the competition, three BlueROV2 platforms will be available at UJI. Groups of 4-5 students will be made and each group will have access to one robot. The sensors available for the inspection task are IMU, camera and depth sensor. These sensors can be easily accessed using ROS (Robotic Operating Systems). With these tools, students will be able to develop a Python script that will subscribe to the sensor topics and will publish on the thruster's topic.

To get students started on the inspection task, a simulator was developed by using Unity and the Unity Robotics Package. This simulation contains a scene of the water tank at CIRTESU with the real dimensions of it, as well as other objects that will be used on the tasks. The model of a BlueROV is also included in the scene. With the help of the "Unity Robotic Package", the robot publishes its virtual camera and can also be moved using ROS commands via a speed topic. Fig. 3 shows the scene created.

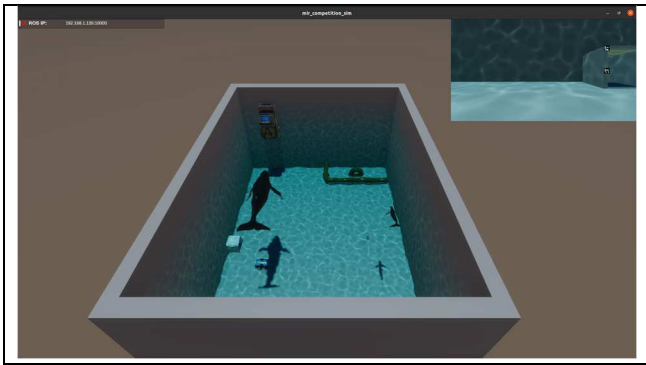


Fig. 3. CIRTESU tank scene developed by using the Unity simulator.

By means of this simulation, students should develop a solution for three different missions: "Autonomous docking"; "Whale inspection"; and a "Companion robot mission".

A. Autonomous Docking

The robot should locate and find the docking station. The station has 5 fixed ArUco markers, one in each corner and the last one at the back middle. Using computer vision, the robot must go inside, and stay there for 30 seconds, avoiding walls collision. A cube docking station (1m side), is available. In the down corner of Fig. 4, the BlueROV is performing the docking, and in the upper right corner, the virtual camera is shown.



Fig. 4. Autonomous docking mission

B. Whale Inspection

The robot should be able to inspect the whales without hitting them. To solve this task, the students must develop a navigation routine where safety is a priority and try to get the best possible angles to study the behavior of the animal. Fig. 5 shows how the inspection is expected; also, in the upper right corner the user can see the image that is going to be used for the whale behavior study.

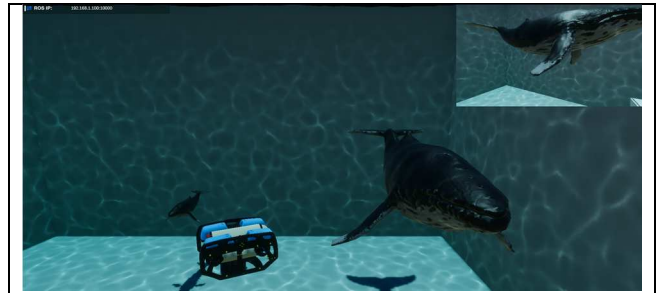


Fig. 5. Whale inspection.

C. Companion Robot Mission

This task simulates an inspection and recovery task, where the robot should be able to localize the control panel and stay, in front of it, for 10 seconds. This simulates the robot receiving information via acoustic communication. The information that the robot is receiving is about the object target that is going to recover. Once the information is received, the robot must navigate through the water tank and locate the appointed target. There are three different targets, the yellow pipe, the red butane cylinder, and the giant seashell.

As can be observed in Fig. 6, the robot facing the control panel (i.e., receiving the target information) is shown. In the bottom right corner, one of the possible target objects is shown (i.e., the green pipe).



Fig 6. Companion robot mission

Finally, students engaged in this championship are required to develop a presentation, including video demonstration, and a free format written report, which will be used to evaluate their work. It is worth noting that this assessment will be considered for establishing the final ranking of each student’s team, in the trials, prior to the runs on the real scenario, which will be conducted in UJI this June 2023.

In particular, the tasks for the physical part of the competition that will be tested with the real robots are like the virtual ones (explained before), but in this case, only two missions will be available. See further details in the following.

A. Autonomous Docking

In the case of the real task, the BlueROV should manually navigate, from one side of the water tank to the other one, where the ArUco codes are located. Once the ArUco codes are visible in the camera, the autonomous docking script, previously implemented, can be tested. The objective is to locate the robot, just in front of the structure, with the ArUco codes, for 30 seconds. Fig. 7 shows an image, taken from the camera of the robot, when it is detecting the ArUco codes.



Fig. 7. ArUco codes detection by the camera of the BlueROV

B. Object Detection

The last task is to detect a replica of an airplane ‘black box’. The ‘black box’ will be at the bottom of the tank, and the robot must locate the box using the camera, the IMU and the depth sensor. The task must be an autonomous localization. Once the object is located the robot must take some pictures of the object and warn the operator that the object is detected. Fig. 8 shows a screenshot, when the target (i.e., airplane black-box mockup) is detected from the BlueROV on board camera. And, Fig. 9, the same scene from an external camera viewpoint.



Fig. 8. Object detection by using the BlueROV on board camera.

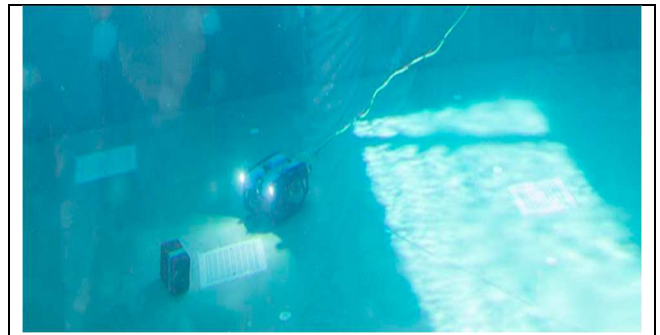


Fig. 9. Object detection by using an external view.

V. CONCLUDING REMARKS

A brief review, along this paper, has been presented, showing work in progress of both, main MIR activities at UJI (present academic course 22/23): the ordinary 2nd year for a subset of 1st promotion students (currently working in their MSc Thesis); and ongoing MIR Championship, affecting those students belonging 2nd promotion, presently at UTLN (France). Obviously, the big picture will be available after carried out the “MIR Annual Symposium and Championship” (UJI, June 2023).

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