Project-Based Learning Aimed at Master's Students in Intelligent Marine Robotics

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INTRODUCTION

The project-based learning approach is a very interesting tool that is becoming increasingly important in different areas of knowledge, including intelligent robotics. The present work is presenting some results, in such a context, applied to students of MIR (Erasmus Mundus Joint Master's Degree in Marine and Maritime Intelligent Robotics) [1], at University Jaume I (UJI) in Spain. Thus, after a successful experience during the academic course (2022-2023), in which the "MIR Annual Meeting & Robotics Challenge" was organized by UJI (June 2023) [2], a new contribution is now presented that addresses project-based learning, during the current academic year, hoping that the reported experience will be useful for the Robotics Community.

ROBOTIC CHALLENGE: "THE SEARCH AND RECOVERY PROBLEM"

Below is a brief explanation of the project to be followed both from the point of view of the visualized concept (Fig. 1) and from the explanation of the roadmap (Sequence of Milestones to be achieved):

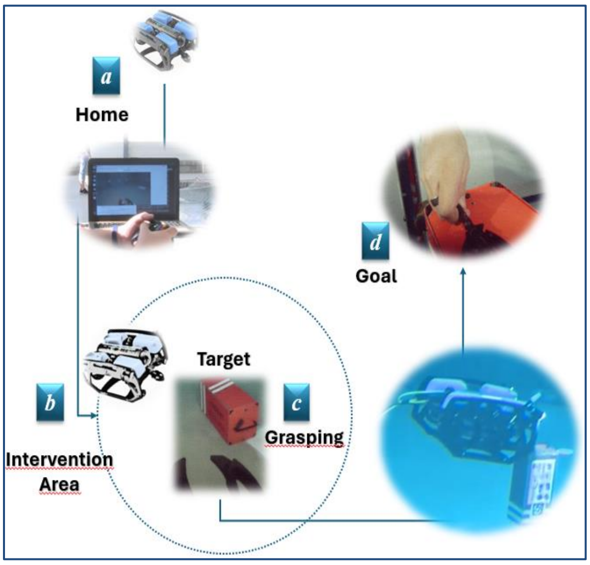

Figure 1. Envisioned Concept of the project to follow

M-1.- Navigation. The purpose here is to design and implement a suitable GUI to teleoperate the vehicle between the "*Home position*" (*a*) and the "*Intervention area*" (*b*).

M-2.- Approach. This step requires the implementation of an autonomous behavior guaranteeing the visually guided approach to the target, driving a displacement between (*b*) and (*c*) locations. ArUco markers are suggested for reducing complexities in this step.

M-3.- Grasping. Another autonomous behavior is required to succeed with the grasp of the target in location (*c*). So, a visually guided grasping strategy is suggested, that can be implemented assisted also through ArUco markers if needed.

M-4.- Transport. After successfully completing the required grab, the mission now is to transport the target to the surface, between (*c*) and (*d*) locations.

M-5.- Recover. Once the surface is reached, the target is recovered by the final user in (*d*) location.

It is worth mentioning that there are some technological limitations in the available vehicles that make solving the problem in question a real challenge for the students. Considering that the BlueROV2 used for the intervention has only 4 actuated DoF (surge, sway, heave, and yaw), the manipulator (a customized Newton Gripper) is fixed to the base with no DoF, and there is no localization system for the robot in the XY plane. The only sensors available are the depth sensor, IMU, and camera. These constraints therefore make the project more challenging and push students to develop stronger autonomous behaviors and innovative ways of approaching the problem.

METHODOLOGY TO FOLLOW

The course begins at UJI in September 2024, and students must complete a total of 30 ECTS in this first semester of their second year. As part of the student's teaching-learning strategy, a practical project is designed that encompasses central aspects of different subjects, with the aim of the student acquiring practical skills that would otherwise be impossible. Thus, the six students are divided into three teams of two, and each team has at its disposal the necessary resources to assemble a hybrid-operated intervention vehicle, based on the BlueROV2, from Bluerobotics[3]. For this reason, students initially work on mechatronic integration, since the equipment comes disassembled, just as it is transported by the company. This helps the students to familiarize themselves with the hardware of the ROVs. Once the basic integration part is finished, and the underwater vehicle, including sensors and manipulator integration, is obtained, they focus on the design and implementation of the most suitable end effector for the required task (i.e. the black box handle grip, Fig. 1). This last objective requires the use of CAD tools [4] and 3D printing resources. Once this step related to the mechatronic effort is completed, the development phase of the algorithms and software necessary to meet the mission objectives begins.

In short, the main goals to achieve, through this project, would be the following:

Supervisory HRI: Implement a 3D Human-Robot Interface that enables the user to launch high level autonomous tasks, while still being able to take low level control of the robot under unexpected situations, in a supervised manner.

Perception: Computer Vision Algorithms for enabling the visually guided approach to the target (i.e. Black Box Mockup), the suitable characterization of the target and implementing some visually guided manipulation actions (see the next).

Manipulation: Implement a Grasp Planner for approaching, grasping, lifting and transporting the target.

Finally, from the teaching viewpoint, there are three main activities to evaluate the students' progress, consisting of two different oral presentations (OCT and NOV), and a final demo (DEC) where each team demonstrates, in real conditions, the performance of their intervention systems.

Figure 2. (Top) The students working in the Lab control room. (Bottom) One of the teams testing the vehicle in the water tank, trying to reach the intervention area (for recovering the “black box”) using teleoperation.

DISCUSSION

At the time of presenting this contribution and following the plan mentioned above, the teams continue working (Fig. 2), having made the two oral presentations required by each of the teams, only the final demonstration remaining, which will be carried out in the available water tank. In this way, we hope to present the latest results in the final paper and, after an appropriate analysis, to be able to show the lessons learned through this project-based learning experience in the context of the MIR at UJI. We are convinced that this experience will be very useful for other universities involved in similar teaching-learning domains.

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