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YOLOv8-based Sea Urchin Detection in ROS for AUV Applications

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***Abstract* – This article presents an online ROS-integrated YOLOv8-based sea urchin detector for Autonomous Underwater Vehicles (AUVs). In order to validate the performance of the system, a realistic simulation environment has been generated using the Stonefish simulator. The simulation setup, including the vehicle and the environment, recreates both the sensors and actuators of the AUV explorer in order to be able to run the detection algorithm under simulation.**

Keywords - Autonomous Underwater Exploration, Online Object detection, Simulation environment

I. INTRODUCTION AND OVERVIEW

The seas and oceans cover most of the surface of our planet. Despite this, most of these regions are still unknown to mankind due to the difficulties of exploring them. The exploration of unknown marine areas has been extensively studied during the last decades. The use of robotics systems such as Autonomous Underwater Vehicles (AUVs) or Remote Operated Vehicles (ROVs) has become increasingly popular due to their advantages over other exploration techniques. Despite this, marine robotic exploration is generally characterised by a number of limitations, mainly due to the inherent characteristics of the marine environment itself. Some of these limitations are the difficulty in locating the vehicles, the communication or computing capacity. Given these limitations, in many cases a preliminary step to experimentation in real environments is to test the systems in simulated environments. Simulated environments allow testing different implementations in a controlled environment, overcoming the limitations present in real environments.

The work presented in this article is part of the CONBOSER project. The CONBOSER project aims to use autonomous marine robots and artificial intelligence to assess biodiversity, conservation status and the role of marine reserves in contributing to the maintenance and improvement of biodiversity and ecosystem services of three key habitats of the coasts of the Balearic Islands: Posidonia oceanica meadows and Cymodocea nodosa and Cystoseira forests. In addition, the project will also quantify the number of invasive algae and sea urchins present in different marine areas of interest in order to assess how these species affect the Posidonia oceanica, Cymodocea nodosa and Cystoseira forests.

This paper presents preliminary work on the implementation of a simulated autonomous marine exploration using an AUV and the design of an online object detection algorithm in order to detect, quantify and locate objects of interest present in the region. The objectives of the article are: a) Define a simulation setup and environment, b) Perform an autonomous unknown marine area exploration using an AUV, c) Online object detection and geolocalization d) Quantification of detected objects of interest.

II. SIMULATION FRAMEWORK

The simulation system uses a Sparus II robot, a torpedo shape AUV represented in Figure 1. Sparus II is extensively described in terms of hardware and software in different articles. Authors in Carreras et al. [1], describe the Sparus II AUV hydrodynamic model and define the main hardware characteristics of the vehicle.

Fig. 1 Sparus AUV. Left: real Sparus II AUV. Right: simulated Sparus II in the simulation environment introduced in the Stonefish simulator

The work done by Palomeras et al. [2] presents a control architecture for AUVs called Component Oriented Layer-based Architecture for Autonomy (COLA2), which is used by Sparus II. It is worth mentioning that the COLA2 architecture is open source and based on Robot Operating System (ROS) [3]. In terms of the simulation environment, our work uses the Stonefish simulator [4]. Stonefish incorporates hydrodynamic calculations using real body geometry to more accurately estimate hydrodynamic forces. The custom rendering pipeline ensures lifelike representations of the atmosphere, ocean and underwater environments. Stonefish also allows the data sensing from different simulated sensors including stereo cameras. We will use this simulation feature to enable AUV to detect objects during the exploration process. The objects of interest to be detected by the AUV during the exploration process shall be sea urchins. Stonefish allows configuring the simulation environment, thanks to this feature we were able to introduce an artificially generated scenario with different sea urchins randomly scattered around the environment as can be seen in Figure 2.

III. OBJECT DETECTION

As previously mentioned, a primary goal of the CONBOSER project is the identification and quantification of species of interest within specific habitats. Within this framework, deep learning techniques have been applied to address the detection and quantification of sea urchins, a key species of interest. Specifically, we have utilized the yolov8n object detection network [5], which has been trained on publicly available datasets of sea urchins. Yolov8n is a cutting-edge deep learning model designed for efficient and fast object detection. It can adeptly learn to recognize objects in images, providing instance bounding boxes along with their classification score and detected class. To seamlessly incorporate this model into the project's broader framework, it has been integrated in ROS by creating a custom message that contains the detected urchin information (bounding box, latitude, longitude, class and confidence score). The ultimate aim of this integration is to deploy the system on an AUV onboard PC, enabling the generation of biodiversity maps. As part of the testing phase, a simulation scenario mimicking the Mediterranean seafloor, containing sea urchins, has been meticulously constructed. Using the stonefish simulation, a survey has been programmed for the simulated robot. This survey serves the dual purpose of evaluating the network's performance and assessing its integration within the ROS framework. Figure 2 shows examples of simulated urchins belonging to the stonefish scenario successfully detected by the ROS inference node when performing online inference using the trained yolov8n network.

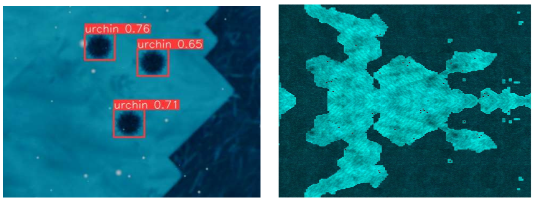

Fig 2. Left: Inference examples of the trained yolov8n network during the online execution in the Stonefish simulation. The generated bounding boxes along with their confidence score are displayed. Right: Simulation environments mimicking a seabed containing sand, Posidonia oceanica and sea urchins.

IV. RESULTS AND CONCLUSIONS

This study introduced the implementation and deployment of a sea urchin detector using yolov8n neural network under a simulator. The successful integration of this network into the ROS framework enabled online inference and data storage within a ROS node. Utilizing Stonefish simulation, we validated the system's capability to detect sea urchins and accurately record their positions. These achievements laid the foundation for the generation of biodiversity maps, demonstrating the potential of the developed pipeline for monitoring and conservation efforts in marine ecosystems. Moreover, the use of simulated environments has proven to be useful for testing and refining the developed algorithms in a simulated environment before real deployment.

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