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Exploring Deep Waters: Preliminary Findings and Design Insights from a Stereo Vision Unit Deployment

Caterina Muntaner-Gonzalez, Eric Alfaro-Dufour, Antonio Nadal-Martinez, Antoni Martorell-Torres, Miguel Martin-Abadal, Francisco Bonin-Font

Systems, Robotics and Vision, University of the Balearic Islands, ctra de Valldemossa, km 7.5, Palma de Mallorca, 07122, Balearic Islands, Spain

Abstract – This paper presents preliminary data and results from field experiments in which a stereo-camera-unit was deployed at approximately 100m depth, capturing images of sea fauna. The stereo vision system is described, as well as the image processing techniques used to enhance brightness and facilitate fish detection.

Keywords – Stereo Vision System, underwater, benthic lander, fishes.

I. INTRODUCTION AND OVERVIEW

Monitoring marine biodiversity is a key aspect in a context of growing anthropic impact across the entire breadth of continental margins [1]. In this context, benthic landers have become a popular choice for deep-sea ecosystems monitoring due to their advantages over other techniques such as Remoted Operated Vehicles (ROVs).

The work presented in this paper is part of the national PLOME project. PLOME proposes a spatially adaptive, non-invasive, modular platform of independent and wirelessly connected benthic stations and AUVs to intelligently observe, monitor and map marine ecosystems over long-lasting periods with real-time supervision. Therefore, complex ecological indicators will be computed from the collected data, by applying advanced computer vision techniques to classify, count and size individuals in video images and to generate multimodal maps of the seabed.

In this paper, we present data and results obtained from a Stereo Vision System (SVS) using a benthic lander as the deployment system. The aim of the experiment is to record different types of marine species and afterwards, process the obtained data and apply a neuronal network to detect the type of fauna recorded.

II. MATERIALS AND METHODS

The equipment used to perform the experiments consisted of a SVS integrated into a benthic lander (see Fig. 1). The USB3 Chameleon cameras had 5mm focal length lenses, were physically synchronised and powered by a high-capacity 14.8V 70Ah Li-Ion battery. An Intel Nuc Pro12, running on Ubuntu 20.04 and ROS in Noetic version, was used to process all data received from the cameras. This minicomputer featured a 12-core i7 processor with an operating frequency of up to 4.7 GHz, 16GB of RAM, and 2TB of storage capacity. The system included two LED lights controlled by an Arduino Nano via GPIO pins. Both lights were powered by the battery, while the micro-controller power supply came directly from the NUC. The electronics were safeguarded by a high-pressure resistant enclosure, which provided durability up to a depth of five hundred meters.

Fig 1. Benthic lander equipped with the Stereo Vision System.

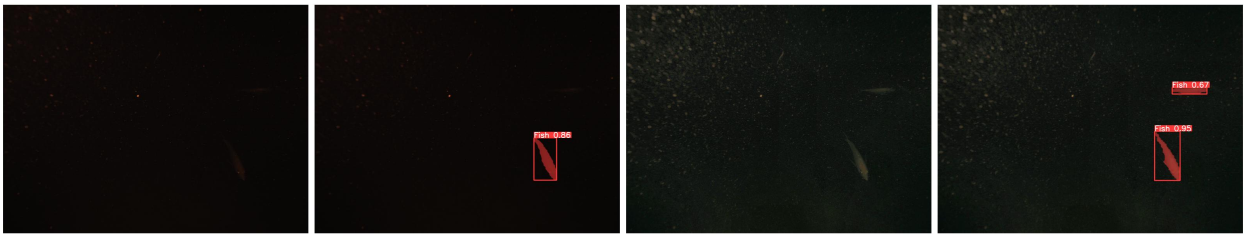
Experiments were conducted off the coast of Catalonia aboard the 'Sarmiento de Gamboa' ship. The benthic lander, equipped with the SVS, was deployed at a depth of approximately one hundred meters below the surface and remained submerged for twenty-four hours. More than twelve hours of images were recorded during the experiment, which were subsequently post-processed in the laboratory to improve brightness. The image enhancement process performed is described below.

First, since all the images have an excessive reddish hue, we decided to reduce the intensity in the red channel of the image by 40%. After this, we applied a color space change from RGB to HSV, to improve the illumination of the image by making modifications on the value channel (V). This is achieved by applying a Contrast Limited Adaptive Histogram Equalization (CLAHE) [2] to that channel. The above process is illustrated in Fig. 2.

(a) (b) (c) (d)

Fig 2. (a) Image captured by SVS, (b) after applying red channel intensity reduction, (c) after applying CLAHE once, (d) after applying CLAHE twice.

By making use of the post-processing mentioned above, we have managed to improve fish detection, both in terms of confidence and in number of detections, as can be seen in Fig. 3.



(a) (b) (c) (d)

Fig 3. (a) Image captured by SVS, (b) detection performed using captured image, (c) image after applying CLAHE twice, (d) detection performed using post-processed image.

III. CONCLUSIONS

This work presents the results of the deployment of a SVS during the first PLOME campaign. The developed system demonstrated endurance at a depth of one hundred meters, remaining underwater for twenty-four hours. The experiments collected a significant amount of data, observing various marine species, including fish, crustaceans, and worms. The preliminary image enhancement techniques applied have proven to improve image quality and fish detection performance. Future work aims to enhance the illumination system to provide more brightness to the observed scene and to avoid the need of post-processing the recorded images. Moreover, image processing techniques will be applied to manage the issue of water turbidity.

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