ID08 BENTHOSEARCHER: A MACHINE LEARNING BASED TOOL TO ULTRA-FAST, AUTOMATIC CHARACTERIZATION OF VULNERABLE MARINE ECOSYSTEMS

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ABSTRACT

The degradation and impoverishment of the seabed that has been detected during last decades is the result of numerous variables, among which are uncontrolled exploitation of the seabed concerning its vulnerability, based on trawling gear. Intending to bring the situation under control, European fishing authorities have concluded a series of proposals to promote, define and defend Marine Vulnerable Ecosystems (VMEs), among which one of the most controversial and with the greatest social and economic impact is the veto of trawling in numerous fishing areas/grounds that currently are exploited by a large c number of vessels from many countries of the EU, which see their livelihood in danger. In the process of proposing an alternative that is attractive to both parts, we propose an automatic, real-time tool (BentoSearcher) based on artificial intelligence so that trawlers have will have the autonomy to decide whether or not to cast the net on the seabed in which the vessel is operating based on the data of benthic species detected in previous fishing hauls or trips that characterize and allow to identify vulnerable seabeds.

Keywords – Machine Learning, Vulnerable Marine Ecosystems, iObserver, Trawling Gear.

INTRODUCTION

From the point of view of ecology, there is no longer any doubt that there are several significant challenges that humanity currently faces, one of them being sustainable fishing to achieving development that safeguards food security, livelihoods, human dignity and natural resources. In recent years, different regulations have been implemented to solve the problem but not without facing numerous controversies. So, sustainability is a basic premise and a key pillar of the economic and social future of European fisheries, and the main objective of the Common Fisheries Policy (CFP) of the EU [1] that incorporated a ban of fish discards, i.e., the volume of unwanted captures returned to the sea for different reasons, by introducing the so-called Landing Obligation (Article 15 of the CFP). This states that all catches of regulated species (species under Total Allowable Catches - TAC, or Minimum Conservation Reference Size - MCRS) must be kept on-board, landed, and counted against quotas. From our scientific activity, we have designed, and implemented an automatic electronic monitoring (EM) system based on artificial intelligence and ultra-fast image detection to identify and quantify in real time total catches (retained + discards + by-catch) in the fishing park called iObserver [2]. It has shown good results on-board trawlers even in a problem as complex as the detection of fishing haul images in a trawler's fishing park, in which overlapping and wide species diversity are major challenges that have been faced.

In this work, we take advantage of the strategy and the concept followed by iObserver to develop an ultra-fast detection and identification tool for benthic species caught during trawling as a non-invasive monitoring tool to characterize VMEs called BentoSearcher. To this aim, we have created a strategy based on the iObserver hardware and a convolutional neural network that uses transfer learning. The developed U-Net is based on the success of this type of configuration in semantic image segmentation tasks [3]. The input to the convolutional network is an image. The output is a semantic segmentation of the input image, in which the masks attributed to each class to be identified can be located. Initially, a training of the neural network will be configured based on the selection, and manual segmentation, of images of characteristic species of vulnerable seabeds that are obtained from the set of iObserver images obtained during a research campaign (Flemish Cap 2022) carried out in collaboration with the Spanish Institute of Oceanography (IEO) in the NAFO fishing ground - Division 3M in July and August 2022. To help in the validation stage, the detection performance has been tested in artificial images built as a mosaic with original iObserver images. Finally, the detection capacity of 12 species has been verified, including 8 vulnerable benthic species and 4 actiniae species characteristic of vulnerable seabeds.

METHODOLOGY AND RESULTS

As a starting point, 12 target species have been selected, among which are 8 that are classified as vulnerable due to their slow growth or low reproductive capacity, and another 4 among which are several actiniae species characteristic of vulnerable seabeds:

Group 1: Stauropathes arctica; Flabellum alabastrum; Anthoptilum grandiflorum; Funiculin quadrangularis; Halipteris finmarchica; Heteropolypus sp.; Polymastia sp.; Histodermella sp.

Group 2: Ceramaster granularis; Hippasteria phrygiana; Stephanauge nexilis; Didemnidae

Once the images of interest for training were selected, first filtering was done using a Python routine to clarify the images. This task facilitates the manual segmentation that is accomplished by using LabelMe. This segmentation is based on the elaboration, using polygons, of a mask for each species detected in a selected image. Thus, each species has a mask colour associated with it. The images, and their respective masks, are subjected to an image augmentation process using the Python Imgaug library. Finally, 1,995 images and their corresponding masks for the 12 target species are set.

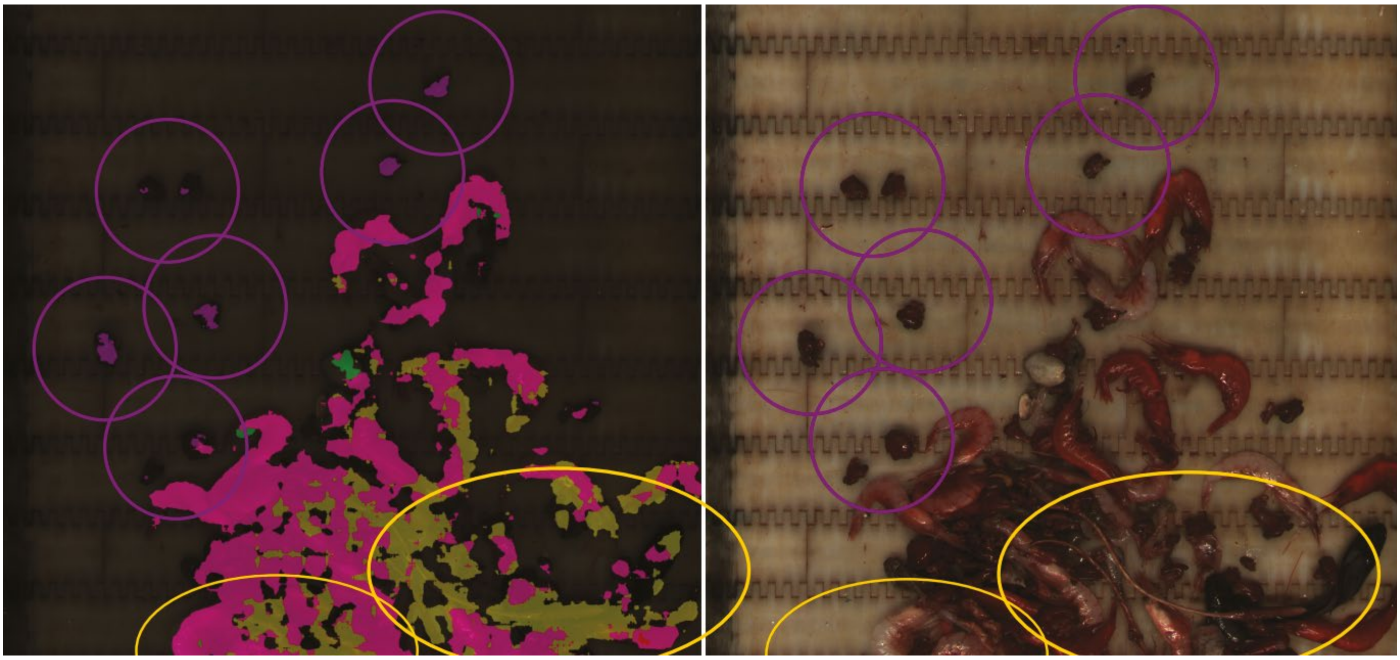

Fig 1. Real application of the BentoSearcher trained for 300 epochs to an image of high heterogeneity in species present. Anthoptilum (yellow) and heteropolypus (purple) masks have been successfully detected. The magenta mask segments all species listed in others.

The generated set of images and masks were used for training a U-Net. The configuration of the U-Net is based on the use of MobileNetV2 for the encoding part and a set of concatenation layers in the decoding part. The training was carried out for 300 epochs using 64 cores of 2 NVIDIA a-100 GPUs provided by Galician Supercomputing Centre (CESGA). The test of the predictive capacity for the semantic segmentation of images has been put to the test with different original campaign images in Flemish Cap. Figure 1 presents the masks generated by the trained neural network of an image with high heterogeneity in species. We visuallyidentified with the presented first version of the BenthoSearcher the two target species, anthoptilum (yellow) and heteropolypus (purple) present in the haul image taken by the iObserver. The pink masks would belong to the "others" group, including everything that is not a target species.

CONCLUSIONS

An automatic, real-time artificial intelligence-based tool called BenthoSearcher for the ultra-fast monitoring and detection of characteristic species of vulnerable seabeds and VMEs has been presented. The trained neural network has shown high efficiency in detecting species, even in highly heterogeneous images. The system should be subjected to more intensive training regarding the species in the "others" group. In the same way, it is necessary to establish a correlation between the number of pixels detected for each species and a threshold value from which the seabed on which work is being done must be characterized as vulnerable.

REFERENCES

[1] Document 32019R1241. Regulation (EU) 2019/1241 of the European Parliament and of the Council.

[2] Juan Carlos Ovalle et al., "On the use of deep learning for fish species recognition and quantification on board fishing vessels", Marine Policy, vol. 139, pp. 105015, 2022.

[3] Olaf Ronneberger et al., U-Net: Convolutional Networks for Biomedical Image Segmentation, arXiv:1505.04597, 2015.