Deep Learning for Semantic Segmentation of Coral Images in Underwater Photogrammetry

Ming Li[1,2], Armin Gruen[1], Hanqi Zhang[2]

[1]*Institute of Theoretical Physics,*
ETH Zurich. 8093, Switzerland, mingli39@ethz.ch, armin.gruen@geod.baug.ethz.ch
[2]*State Key Laboratory of Information Engineering in Surveying, Mapping and Remote Sensing,*
Wuhan University, 430074, China, hqzhang@whu.edu.cn

Abstract: Coral reefs are undergoing rapid changes as a result of increasing ocean temperatures, acidification, eutrophication, and chemical pollution. Regular monitoring activities are important for assessing the influence of unfavorable factors on corals and tracking subsequent recovery or decline. Monitoring by field surveys provides accurate data but at highly localized scales and so is not cost-effective for coral reef scale monitoring at frequent time intervals. Satellite and UAV remote sensing are alternative and complementary approaches, while remote sensing on coral reefs from satellites and drones cannot provide the level of detail and accuracy required. In order to get 3D accuracies in the order of a few mm we have to apply underwater photogrammetry, with images at fairly large scale. Deep learning-based underwater photogrammetry provides a comprehensive solution for large-scale and precise monitoring. It can quickly acquire a large range of underwater coral reef images. These images are passed through a self-calibrating bundle adjustment to generate an accurate 3D object model. The identification of the different corals and their distinction from dead corals and other objects is achieved through advanced image preprocessing and coral annotation technologies. Finally, through a semantic segmentation method based on deep learning, the population number and distribution of different corals in the study area can be obtained. In our research, the experimental data is a seabed coral image set of Moorea Island. By adopting a reasonable data set division and preprocessing method effective edge information is retained and the problems of lack of coral image data and low contrast of coral borders are overcome.
This paper applies three state-of-the-art convolutional neural networks (Unet, SegNet, and Deeplab V3+) to the semantic segmentation of corals, compares their performance, and proposes a new improved method. Finally, in order to quantitatively describe the performance of the semantic neural network in this experiment, this paper uses the neural network model evaluation index of mean intersection over union (mIoU) ratio and pixel accuracy (PA). The proposed trained network can accurately distinguish living from dead corals, which could reflect the health of the corals in the area of interest.

Keywords: Coral images; semantic segmentation; Convolutional Neural Network(CNN); deep learning, underwater photogrammetry