SG219 – Deep corals, deep learning: novel application of advanced neural network analysis for environmental monitoring

Research Highlights The MASTS Small Grant enabled us to launch a state-of-the-art research project on using artificial intelligence in ocean ecosystems. Our main objective was to trial the use of AI techniques, specifically deep learning, to solve the Big Data problems in deep ocean ecosystems associated with annotating (counting organisms) images from photos collected by underwater cameras. The highlight of our research is that our new algorithms are far faster and better (and less expensive) than humans at annotating images from the deep sea: ***286,600 seconds versus less than 1 second to annotate 159 images with 93% accuracy in identifying and discriminating between marine features like corals, sponges and substrata***. The algorithm and approach are generally applicable to any kind of Earth imagery, not just the coral reefs we studied. Following on from this grant, we are now investigating whether we can make this algorithm on-board on autonomous platforms like AUVs in order to annotate in real-time: this would eliminate the months to years of human time and expense to conduct these at times quite tedious (let's face it, there's a lot of mud down there!) annotations.

The Challenge Exploration of the deep ocean uses sophisticated underwater technologies such as benthic landers, remotely operated vehicles (ROVs) and autonomous underwater vehicles (AUVs). The images and video they return provide repositories of Big Data that experts must then process to assess policy-relevant metrics such as species occurrence, richness, turnover and density. Image annotation is time-consuming, costly to put into effect, and highly subject to differences in expert opinion. As industry expansion into the deep-sea and High Seas continues, so does the need for robust cost-effective methods to annotate these images, alongside the urgency for solving the challenges that Scotland and the UK face in meeting its obligations to OSPAR and the Convention on Biological Diversity.

Deep learning Like the human brain, the more data the computer learns from, the better it becomes at discriminating between feature classes. Deep learning is now used by global enterprises such as Google, Amazon, and Facebook to recognise patterns in speech and faces. In ecology, it is used to classify sounds produced by birds and marine mammals.

The team The work merged two fields of expertise in engineering and biology:

<u>*Automated image classification*</u>

- Dr. Neil Robertson, Queen's University Belfast
- Mr. Mohamed Elawady, Erasmus Mundus European Masters in Vision and Robotics student at Heriot-Watt University
- Dr. Rick Mukherjee of AnyVision, Heriot-Watt University

<u>*Deep-sea coral annotation*</u>

- Dr. Lea-Anne Henry, University of Edinburgh
- Prof. J Murray Roberts, University of Edinburgh
- Ms. Laurence de Clippele, PhD student at Heriot-Watt University

The work The task began with Mohamed and then Rick using 159 deep-sea images collected by ROV during the NERC-funded "*Changing Oceans Expedition*" cruise (Chief Scientist, Murray Roberts) in 2012 to Rockall Bank, the Logachev and Pisces coral mounds and the Mingulay Reef Complex. The images were annotated by Lea-Anne and Laurence. Image data were augmented and patch-tested to allow simultaneous location and classification of 36 different classes of features to be annotated, notably live and dead areas of the deep-sea coral *Lophelia pertusa*, several species of antipatharian black corals, deep-sea sponges, and different sediment classes (e.g., sand, boulders, gravel, coral rubble). This method used the latest technique of integrating dense conditional random fields with a fully convolutional (connected) neural network, with great success and we hope to soon be able to demonstrate real-time segmentation (classification) of different objects in the deep sea.