Working towards automated marine image analysis

MASTS/WHOI Bridge Programme Report

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Introduction

An array of different variables may affect where a species occupies at a particular stage in its ontogeny. For demersal fish species such variables may include, depth, water temperature, salinity and substrate type. Juvenile gadoids, such as cod (*Gadus morhua*), haddock (*Melanogrammus aeglefinus*) and whiting (*Merlangius merlangus*) migrate to coastal areas during the first few months to a year of their life, following pelagic larval stage (Bailey et al, 2011). Various studies say that the first year of gadoid life is can significantly affect recruitment success (Olsen and Moland, 2010; Ings et al 08) and have therefore focused research to identifying 'essential fish habitats' to help recover stocks (Juanes, 2007). In the UK very little is known about what makes an important habitat for these juveniles. Most studies looking at gadoid abundance and the habitat they might occupy involve coarse trawl survey. This method can lead to loss of information on substrate variability as well a deficiency in information in more rugose substrata and shallow areas due to the trawling accessibility. Detailed behavioural information can also be lost. This PhD has used Stereo Baited Remote Underwater Video (SBRUV) camera and Stereo-Video SCUBA transects to collect data on juvenile gadoids within the Firth of Clyde.

To be able to study juvenile gadoid habitat association, EventMeasure software (SeaGIS) has been used to record all mobile species that passed in front of the cameras during data collection. EventMeasure software enables logging and reporting of events occurring in front of the camera as well as object length measurements to be taken. Habitat analysis has been undertaken using Coral Point Count software (Kohler & Gill 2006). JPEG stills of each SBRUV drop were created and points were overlaid on each still image during CPC analysis. For the SCUBA transect data sets, broad substrate categories were noted along the length of the transect. These methods unfortunately lead to a loss of valuable information about the habitat itself and are time consuming.

In deep sea contexts, where vast numbers of images (tens of thousands) are collected using autonomous underwater vehicles (AUV), automated image analyses have been developed. Here methods such as topic modelling have been developed to characterise 'topics' or substrate types within an image in an unsupervised manner. Whilst at Woodshole Oceanographic Institute (WHOI) between October 20 and 31st 2014, at the invitation of Hanumant Singh of the Deep Submergence Laboratory, we tried applying a specific type of topic modelling developed by Girdhar (2014) (within Dr Singh research group) to the SBRUV and SCUBA images I collected during summer of 2013 and 2014.

Method

To undertake this analysis:

- Stills' of the SCUBA transects were clipped at 1 second intervals, enabling JPEGs of the entire SCUBA transect to be captured (approx. 16,000 JPEGS produced. The JPEG were then cropped to focus on the substrate directly in front of the camera only, using FFmpeg software. This avoided distance objects captured and the water column being modelled.
- Contrast Limited Adaptive Histogram Equalization (CLAHE) was then applied to each image (figure 1B). This process improves the contrast in the images by remapping the images in grey scales increasing the intensity value of the whole image. This helped improve problems of light attenuation and enabled a higher range of intensities to be seen.

- Topic Explorer, a program developed by Girdhar (2014) in Python, was then run (figure 2) containing descriptors such as Realtime Online Spatiotemporal Topic modelling (ROST) and Scale Invariant Feature Transformation (SIFT) to identify similar shapes and texture within each image. Parameters used to run the model included controls for the complexity of the scene; the complexity of the substrate type; and a range in the number of substrate types the topic modeller was asked to model.

A. B.

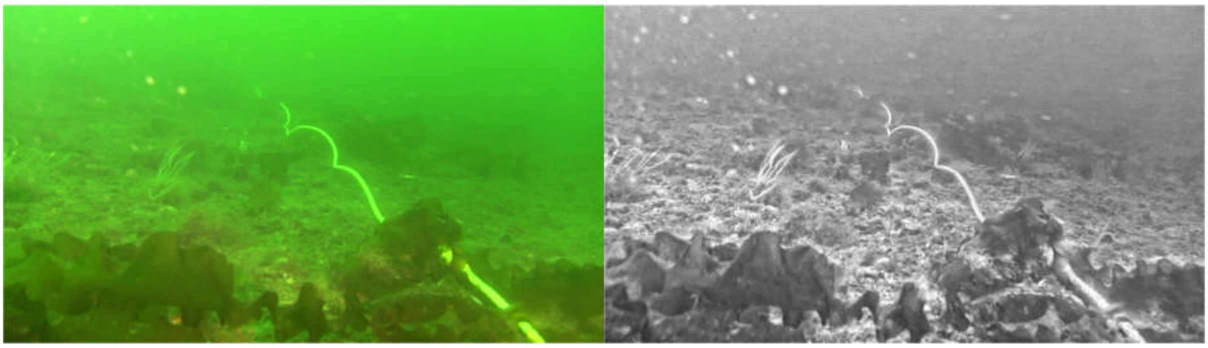

Figure 1: A. A JPEG of a raw image from a SCUBA transect. B. The same image with CLAHE applied to the JPEG

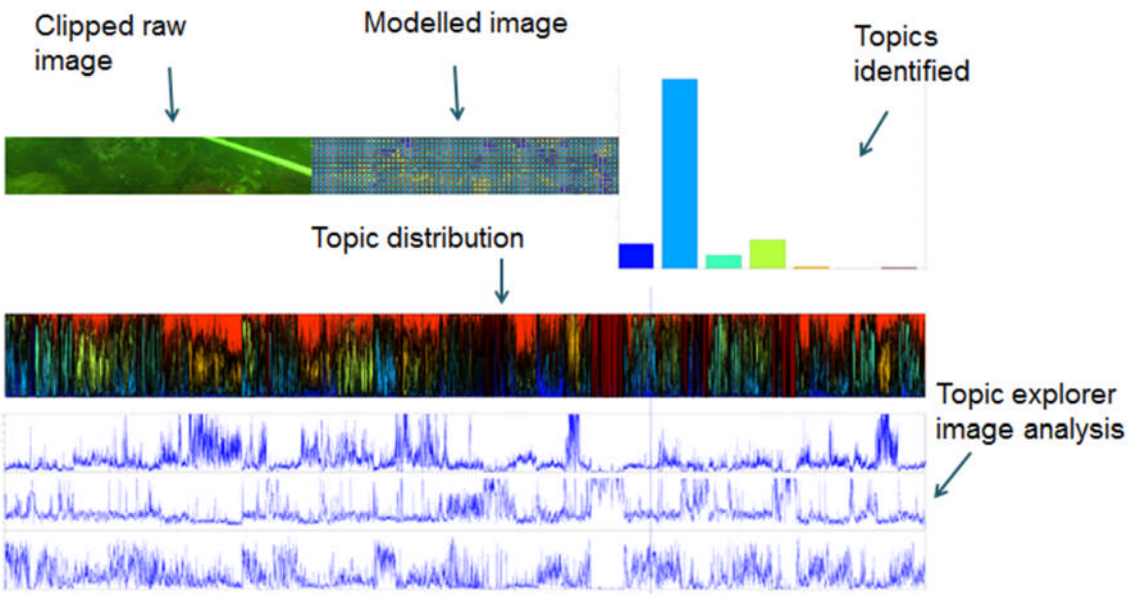

Figure 2. Graphical breakdown of an image by Topic Explorer with graphs comparing the topics identified in relation to other images.

Results and conclusion

Whilst at WHOI, we were unable to find optimal parameters to analyse the images accurately. Topic explorer was able to distinguish different substrate types within an image which matched other images some of the time, however this was not consistent for all images. Hanumant Singh's research group intend to develop illumination and attenuation algorithms to improve the quality of the analysis as well as possibly apply some supervised learning to help with image analysis.

Working with computer scientist experts at WHOI was a great experience and I learnt about a new, developing field of marine biology essential to image analysis work. These methods being developed at WHOI have the potential to greatly improve current methods of image analysis used, particularly with the use of automated vehicles. I would like to give a big thank you to MASTS for the funding and giving me the opportunity to learn more about image analysis, an area poorly developed in Scotland. I would also like to thank Dr Singh and Dr Girdhar for teaching me about topic modelling and spending time with me to try and help improve the image analysis being for this PhD.

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