Automated detection of hydrothermal emission signatures from Multi-Beam Echo Sounder (MBES) images by deep learning

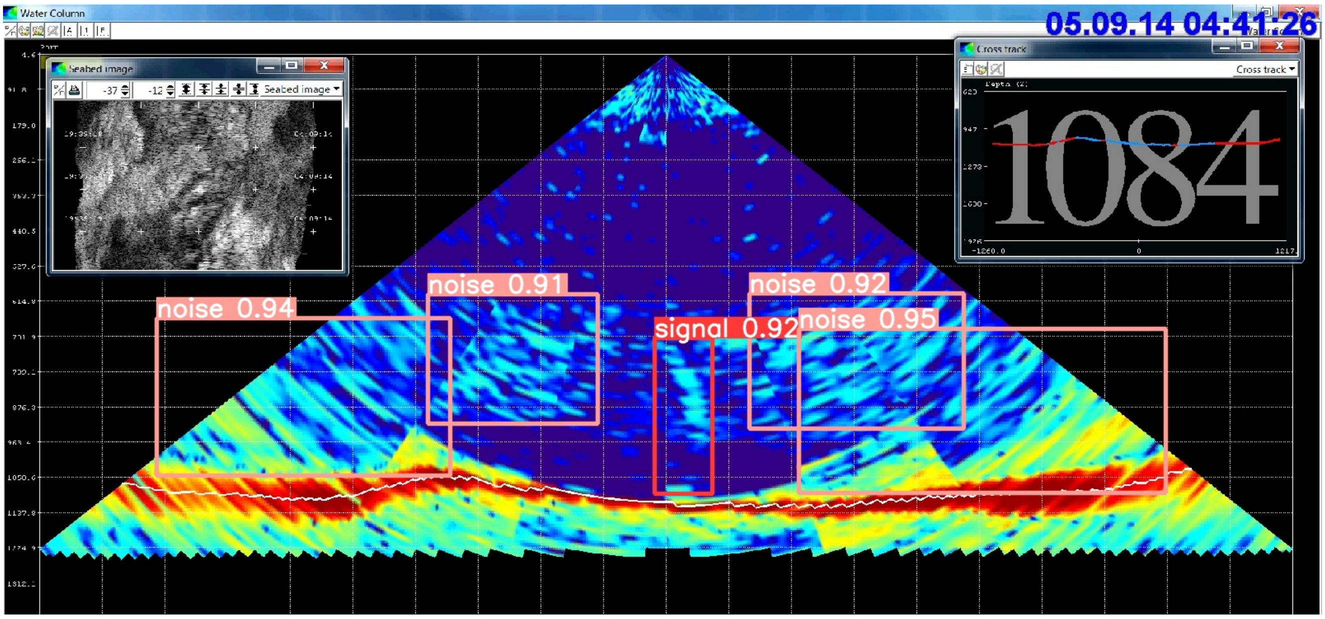
*Kazuhide Mimura[1,2], Kentaro Nakamura[2,1], Kazuhiro Takao[2], Kazutaka Yasukawa[2], Yasuhiro Kato[2,1]

1. Chiba Institute of Technology, Ocean Resources Research Center for Next Generation, 2. School of Engineering, University of Tokyo

Hydrothermal ore deposits are attracting attention as a new mineral resource, because they show significant concentrations of valuable metals including base metals (e.g., copper, zinc, and lead), precious metals (e.g., gold and silver), and other industrially critical metals (e.g., gallium, germanium, and selenium) [1]. Previous studies have shown that the mapping of acoustic water column anomalies in seawater by Multi-Beam Echo Sounder (MBES) is effective for the exploration of active seafloor hydrothermal vents [2]. However, detection of the MBES signals has so far been carried out by visual observation by experts. If this process is automated, the cost performance of exploration for hydrothermal ore deposit can be significantly improved.
From this perspective, we trained deep learning models under ten training conditions to detect the signals from MBES water column images and evaluated their performances. First, we compared ‘Mask R-CNN’ [3] and ‘YOLO-v5’ [4] as architectures of detection models, and found that YOLO-v5 models resulted higher F1 scores. Next, we compared the classes to be trained, and found that models trained with two classes (signal and noise) resulted higher performances than models trained with only one class (signal). Finally, the suitable number of trainable parameters was examined, resulting that the highest performance model was obtained when a large model with ~5×10^7 trainable parameters was used for training, in the condition of two-class training. The best model, revealed by the above comparisons, recorded 0.928 of precision, 0.881 of recall and 0.904 of F1 score. Moreover, the detection speed is 20–25 ms per frame, which is significantly faster than the pace at which MBES images can be obtained (~5 s per frame). Therefore, we conclude that the best model can be applied to the automatic and real-time onboard exploration of seafloor hydrothermal deposits.

References : [1] Boschen et al. (2013) *Ocean Coast. Manag.*, **84**, 54-67. [2] Nakamura et al. (2015) *Geochem. J.*, **49**(6), 579-596. [3] He et al. (2017) *Proc. IEEE, ICVC*, 2961-2969. [4] Redmon et al. (2016) *Proc. IEEE, CVPR*, 779-788.

Keywords: seafloor mineral resources, hydrothermal ore deposit, exploration, machine learning, deep learning, object detection


05.09.14 04:41:26
Water Column
Seabed image
Cross track
1084
noise 0.94
noise 0.91
signal 0.92
noise 0.92
noise 0.95