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Segmentation of sonar imagery using convolutional neural networks and Markov random field. (English) Zbl 07165946

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Summary: In this paper, we present a novel method incorporating convolutional neural networks (CNN) into Markov random field (MRF) to automatically segment side scan sonar (SSS) images into object-highlight, object-shadow and sea-bottom reverberation areas. As a widely used ocean survey sensor, SSS provides high-resolution maps of the seafloor. Automatically segmenting SSS in real time can assist the navigation and path-planning of autonomous underwater vehicles. However, for the speckle noise and intensity inhomogeneity in the SSS images, it is difficult to find a robust SSS segmentation method. These facts motivate us to explore efficient CNN architectures to solve these problems. For pixel-level SSS segmentation, to use the context information and the details around a central pixel simultaneously, the CNN with multi-scale inputs (MSCNN) is employed. Besides, to mitigate the impact of the class imbalance problem, two MSCNN training strategies are introduced, which are based on data augmentation and ensemble learning. Furthermore, to take into account the local dependencies of class labels, the results of MSCNN are used to initialize MRF to get the final segmentation maps. Experimental results on real SSS images reveal that the proposed segmentation method outperforms MRF, CNN and semantic segmentation methods such as fully convolutional network and Segnet in segmentation accuracy and generalization performance. Moreover, the efficiency of the proposed method is proved on retinal image dataset.

MSC:

94A08 Image processing (compression, reconstruction, etc.) in information and communication theory
62M40 Random fields; image analysis
62M45 Neural nets and related approaches to inference from stochastic processes
68T07 Artificial neural networks and deep learning

Keywords:

side scan sonar; image segmentation; convolutional neural networks; ensemble learning; class imbalance problem; Markov random field

Software:

DeepLab; Keras; SegNet; TensorFlow

Full Text: DOI

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