Automated *Artemia* detection and length measurement using deep convolutional networks*

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Automated image analysis has attracted much attention in the bioscience engineering field, due to its superiority in processing efficiency and assessment objectivity over manual image analysis [10]. In aquaculture, the brine shrimp *Artemia* is an intensively used cost-effective diet for fish and crustacean larvae, and recently, the number of *Artemia* studies is increasing. *Artemia* objects are usually observed by a stereo-microscope, and conventionally, *Artemia* image analysis tasks are carried out manually, which is rather time-consuming and labor-intensive. It is highly desired to have tailor-made methods for analyzing *Artemia* images. In response to such demands, we focus on two typical *Artemia* image analysis tasks: *Artemia* detection and *Artemia* length measurement.

In many *Artemia* studies, e.g., in a quality assessment of *Artemia* hatching, an automated method for detecting and counting the *Artemia* objects in images would be highly desired, but few works have addressed this challenging task. Recently, deep convolutional neural networks (CNN) have been adopted for object detection [3]. A representative method is the one combining a region proposal module with a deep convolutional neural network (R-CNN method) [2]. But this method entails a considerable redundancy [4], since it uses *anchor boxes* to generate thousands of region proposals. Inspired by the R-CNN method, we propose a so-called Marker-CNN method by combining a target marker proposal network with a CNN-based classifier [8], as illustrated in Fig. 1. In the first stage, instead of generating region proposals by blind anchor boxes, we design a target marker proposal network using a U-shaped fully convolutional network (UNet) architecture [5]. This module can indicate target candidates, separate adjacent objects and obtain the object structural information simultaneously. In the second stage, using a CNN architecture, we design a classifier to classify the target candidates into categories or label as a non-target, thereby obtaining the *Artemia* detection results. Furthermore, we have collected a dataset to train and test the proposed method. Experimental results on test images, which contain 1336 cysts and 3335 nauplii in total, manifest that the Marker-CNN method can accurately detect and count the *Artemia* objects in images, obtaining a detection accuracy of 99.6%. Samples of detection results are shown in Figs. 2(a) and 2(b).

Artemia length is considered a key dependent variable in many *Artemia* studies [1]. For instance, in a controlled pond *Artemia* production, the *Artemia* length

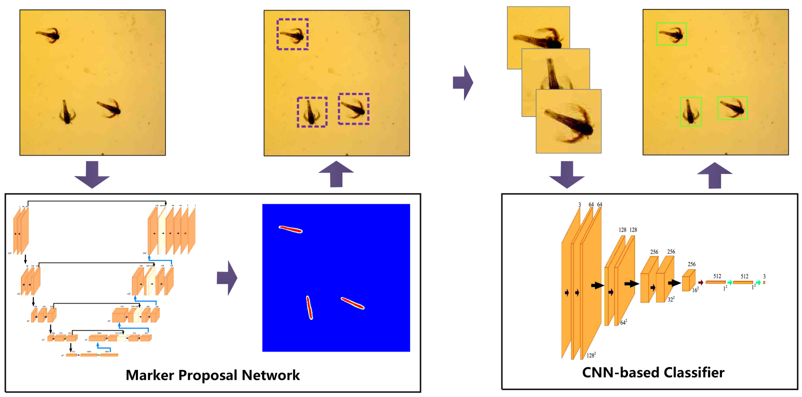

Fig. 1. Illustration of the Marker-CNN method for *Artemia* detection.

is usually adopted as a metric for evaluating the feeding strategies of intensive *Artemia* culture [6]. However, automated *Artemia* length measurement has so far not been addressed. Moreover, conventional image-based length measurement approaches cannot be readily transferred to measure the *Artemia* length, due to the distortion of non-rigid bodies, the variation over growth stages and the interference from the antennae and other appendages. To address this problem, we propose an automated *Artemia* length measurement method [9] using UNet and second-order anisotropic Gaussian kernels [7]. For a given *Artemia* image, the designed UNet model is used to extract a length measuring line structure, and, subsequently, the second-order Gaussian kernels are employed to transform the length measuring line structure into a thin measuring line with minimal loss of length measure. We have collected a dataset containing 250 training images and 100 test images. Experimental results show that our method can accurately measure the length of *Artemia* objects in images, obtaining a *mean absolute percentage error* of 1.16%. Sample results of length measuring line extraction obtained by our method are displayed in Figs. 2(c) and 2(d).

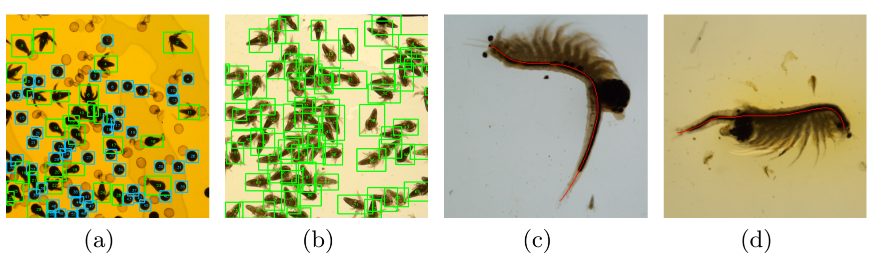

Fig. 2. Samples of detection results (in blue/green rectangles) obtained by the Marker-CNN method (a-b), and samples of length measuring line extraction results (in red) obtained by our method (c-d).

References

1. Balachandar, S., Rajaram, R.: Influence of different diets on the growth, survival, fecundity and proximate composition of brine shrimp *Artemia franciscana* (kellog, 1906). Aquaculture Research **50**(2), 376–389 (2019)
2. Girshick, R., Donahue, J., Darrell, T., Malik, J.: Region-based convolutional networks for accurate object detection and segmentation. IEEE Transactions on Pattern Analysis and Machine Intelligence **38**(1), 142–158 (2016)
3. Han, J., Zhang, D., Cheng, G., Liu, N., Xu, D.: Advanced deep-learning techniques for salient and category-specific object detection: A survey. IEEE Signal Processing Magazine **35**(1), 84–100 (2018)
4. Ren, S., He, K., Girshick, R., Sun, J.: Faster R-CNN: Towards real-time object detection with region proposal networks. IEEE Transactions on Pattern Analysis and Machine Intelligence **39**(6), 1137–1149 (2016)
5. Ronneberger, O., Fischer, P., Brox, T.: U-Net: Convolutional networks for biomedical image segmentation. In: Proceedings of the International Conference on Medical Image Computing and Computer-Assisted Intervention. pp. 234–241 (2015)
6. Lopes-dos Santos, R., Groot, R., Liying, S., Bossier, P., Van Stappen, G.: Halophilic bacteria as a food source for the brine shrimp *Artemia*. Aquaculture **500**, 631–639 (2019)
7. Wang, G., Lopez-Molina, C., Vidal-Diez de Ulzurrun, G., De Baets, B.: Noise-robust line detection using normalized and adaptive second-order anisotropic Gaussian kernels. Signal Processing **160**, 252–262 (2019)
8. Wang, G., Van Stappen, G., De Baets, B.: Automated detection and counting of *Artemia* using U-shaped fully convolutional networks and deep convolutional networks p. Under review (2019)
9. Wang, G., Van Stappen, G., De Baets, B.: Automated *Artemia* length measurement using U-shaped fully convolutional networks and second-order anisotropic Gaussian kernels p. Under review (2019)
10. Xing, F., Xie, Y., Su, H., Liu, F., Yang, L.: Deep learning in microscopy image analysis: A survey. IEEE Transactions on Neural Networks and Learning Systems **29**(10), 4550–4568 (2018)