Title :   Optimization of sample preparation conditions and microscopic Imaging parameters to enhance the precision of YOLO-base marine microalgae detection.

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ABSTRACT

Automated marine microalgae detection from microscopic images is vital for biological and environmental research, reducing annotation bottlenecks and improving reproducibility for downstream analyses such as biodiversity assessment and carbon cycling studies. However, variations in imaging conditions, particularly sample dilution and microscope magnification, strongly affect model performance and generalization. The objective of this study is to investigate the effects of sample dilution and microscope magnification on marine microalgae detection using deep learning–based object detection models. Six microscopic image datasets were constructed based on different combinations of dilution conditions and objective magnifications (10× and 40×), with each dataset consisting of 200 images. Four datasets were used to train YOLOv8-based models using a standardized split of 70% training, 20% validation, and 10% testing, while the remaining two datasets were reserved for cross-dataset evaluation under unseen conditions. Experimental results show that models trained on 40× magnification significantly outperform those trained on 10× magnification. Specifically, mAP50 increased from approximately 0.42–0.46 to 0.93–0.96, and mAP50–95 improved from approximately 0.20–0.23 to 0.70–0.74. Moreover, 40×-trained models consistently achieved higher precision and recall across all dilution conditions, particularly for the marine microalgae class with recall exceeding 0.85, whereas the non-algae class showed greater variability. Unseen-dataset evaluation required confidence and threshold adjustment, highlighting image resolution and domain consistency for reliable detection.

Keywords: Marine microalgae detection, Deep learning, Domain generalization