Comparative analysis of deep learning models for cell counting in microalgae samples

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Abstract

Microalgae have demonstrated outstanding potential across various industries, including pharmaceuticals, biodiesel production, and animal feed, but their widespread adoption remains limited due to challenges in upstream production processes. This research aims to overcome the constraints of traditional microalgae monitoring techniques, where manual cell counting is both tedious and prone to errors, by leveraging deep learning methods to improve the accuracy and efficiency of cell counting. Three object detection models, namely, SSD, Faster R-CNN, and YOLOv8 were evaluated for their effectiveness in microalgae cell counting. These models were specifically selected for their strong potential in accurately detecting a wide range of objects. Among these, YOLOv8 outperformed the others, achieving a maximum F1 score of 0.95, 0.94, 0.97, 0.98, 0.98, and 0.99 for cell count ranges between 0–100, 101–200, 201–300, 301–400, 401–500 and >500 cells, respectively. These findings highlight YOLOv8's effectiveness in accurately detecting and counting microalgae cells with minimal error, as it combines a lightweight design with advanced feature

extraction. In comparison, Faster R-CNN struggles with small objects because it relies on a region proposal network, while SSD faces challenges due to its use of default bounding boxes. Therefore, unlike other works that solely focus on cell classification, this research emphasizes the potential of the YOLOv8 model for cell counting, which assists in identifying microalgae growth phases, a crucial factor in determining the optimal harvest time. Since microalgae produce different biomolecules at each growth stage, this information is valuable for optimizing their applications across various industries. © 2025 Elsevier B.V.

Author keywords

Deep learning; Faster R-CNN; Microalgae detection; Object detection; SSD; YOLO

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Abstract

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