A Novel Application of Attention U-Net for Marine Biofouling Classification and Segmentation

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ABSTRACT

Marine biofouling presents significant challenges in the maritime industry, including increased drag, fuel consumption, and maintenance costs. Traditional inspection and mitigation methods are labour-intensive and time-consuming, underscoring the need for automated approaches of biofouling detection and analysis. Various machine learning architectures, particularly convolutional neural networks (CNNs), have been utilised for this purpose. State-of-the-art semantic segmentation of fouled experimental panels has been achieved with U-Net [1]. Regarding operational data, MFONet, a novel pixel-level segmentation model, was proposed for instance segmentation and was trained on images obtained from a single vessel by [2]. Conversely, a pre-trained CNN ensemble was employed for classification of a more diverse dataset by [3]. The proposed study aims to bridge the existing literature gap by introducing an enhanced Attention U-Net architecture specifically optimised for the semantic segmentation of marine biofouling in operational conditions. The model, proposed in this study, incorporates additive soft attention gates within the skip connections of the traditional U-Net framework. This mechanism selectively emphasizes relevant features by dynamically adjusting the importance of skip connection inputs, reducing noise and improving segmentation accuracy. The model was trained and tested on an annotated dataset of in-water biofouling imagery collected from multiple ship hull surveys, provided by diving companies, classification societies, and NTUA's archive. It contains images captured under various environmental conditions, which enables better model generalisation. Compared to existing literature, preliminary evaluations demonstrate that this approach can improve the performance on both Dice coefficients and Intersection-over-Union (IoU) scores, suggesting an advancement in classification and localization capabilities. The results have promising implications for deployment in automated inspection systems, potentially enhancing the efficiency of hull and offshore structure inspections by reducing manual effort and improving detection accuracy. Our study provides a scalable solution to biofouling monitoring, filling a critical gap in the field and contributing to the growing need for autonomous biofouling management systems in the maritime industry.

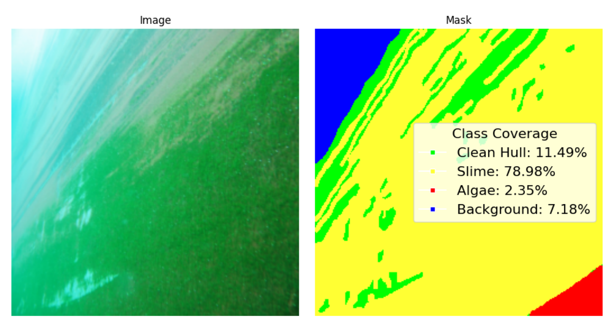

Figure 1: Model's Preliminary results.

References

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