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Bridging Automation and Expert Oversight: A Human-in-the-Loop Approach to Coral Morphology Assessment

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Coral reefs are among the most diverse and valuable marine ecosystems, providing habitat for marine life, coastal protection, and economic benefits through fisheries and tourism. However, they are increasingly threatened by climate change, ocean acidification, and human activities. Understanding coral growth and morphology is critical for assessing resilience and adaptation strategies, particularly in controlled laboratory environments where responses to environmental stressors can be studied. Yet, quantifying morphological traits—such as polyp size and density—remains a tedious, time-consuming task, limiting the scalability of such studies. Automation is needed to accelerate data collection and ensure consistency in morphological assessments across both photographic and CT scan data.

This research presents an interactive, cloud-ready tool that integrates advanced computer vision and adaptive learning for efficient, high-accuracy coral morphology analysis. Using pre-trained object detection and segmentation models as a cold-start approach, our system enables precise quantification of morphological traits from both high-resolution coral images and 3D CT scan reconstructions. Recognizing the limitations of existing models in specialized domains, our tool incorporates expert oversight through human-in-the-loop learning, allowing researchers to refine segmentation outputs, fine-tune models on niche datasets, and improve label efficiency. Additionally, it supports post-processing workflows for morphological quantification, ensuring meaningful, research-ready outputs.

As an interdisciplinary team of marine biologists and interactive machine learning researchers, we co-develop this machine-assisted tool to bridge the gap between manual analysis and full automation. By leveraging cloud-based infrastructure, real-time feedback, and interactive learning, our approach advances coral research, making large-scale monitoring and analysis more efficient, reproducible, and scalable for conservation efforts.