Machine Learning for Coral Bleaching Diagnosis and Forecasting Using Images and Environmental Data

Field, Warren (School: Chagrin Falls High School)

Known as the “rainforests of the sea” coral reefs support over 1 billion people. Yet the rising ocean temperatures have driven increasingly frequent coral bleaching events, threatening reefs globally. Current monitoring techniques often fail to detect bleaching stress before it becomes fatal. This study develops a two-phase artificial intelligence framework that surpasses current diagnostic standards and provides a new window for proactive conservation. In Phase 1, I focused on foundational diagnostic assessment. I developed two convolutional neural networks that achieved 88% accuracy in distinguishing healthy from bleached coral, outperforming established benchmarks. I also optimized five machine learning models for environmental data and tested a multimodal AI. These experiments led to a critical discovery: while images provide the most precise diagnostic signal, environmental data is most effective as an early warning tool. Phase 2 introduces the primary breakthroughs of this research. I developed a novel neural network that classifies coral into a five-level severity scale with a standard-setting 92.9 percent accuracy. With a 0.97 quadratic weighted kappa, this model identifies subtle biological gradations more reliably than previous binary models. Furthermore, I trained five models to forecast bleaching events up to 12 weeks in advance with consistent 75% accuracy, providing managers enough time to intervene. This system transforms reef management from documenting death to preventing it. By using free computational tools, I ensured this high-performance framework is accessible to researchers in resource-limited regions. This study provides a scalable, low-cost solution to identify reef bleaching before damage becomes irreversible.

Awards Won:
Fourth Award of $600