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## **NASA NeMO-Net**

We present preliminary results from NASA NeMO-Net, the first neural multi-modal observation and training network for global coral reef assessment. NeMO-Net is an open-source deep convolutional neural network (CNN) and interactive active learning training software in development which will assess the present and past dynamics of coral reef ecosystems.

NeMO-Net exploits active learning and data fusion of mm-scale remotely sensed 3D images of coral reefs captured using fluid lensing with the NASA FluidCam instrument, presently the highest-resolution remote sensing benthic imaging technology capable of removing ocean wave distortion, as well as hyperspectral airborne remote sensing data from the ongoing NASA CORAL mission and lower-resolution satellite data to determine coral reef ecosystem makeup globally at unprecedented spatial and temporal scales.

Aquatic ecosystems, particularly coral reefs, remain quantitatively misrepresented by low-resolution remote sensing as a result of refractive distortion from ocean waves, optical attenuation, and remoteness. Machine learning classification of coral reefs using FluidCam mm-scale 3D data show that present satellite and airborne remote sensing techniques poorly characterize coral reef percent living cover, morphology type, and species breakdown at the mm, cm, and meter scales. Indeed, current global assessments of coral reef cover and morphology classification based on km-scale satellite data alone can suffer from segmentation errors greater than 40%, capable of change detection only on yearly temporal scales and decameter spatial scales, significantly hindering our understanding of patterns and processes in marine biodiversity at a time when these ecosystems are experiencing unprecedented anthropogenic pressures, ocean acidification, and sea surface temperature rise.

NeMO-Net leverages our augmented machine learning algorithm that demonstrates data fusion of regional FluidCam (mm, cm-scale) airborne remote sensing with global low-resolution (m, km-scale) airborne and spaceborne imagery to reduce classification errors up to 80% over regional scales. Such technologies can substantially enhance our ability to assess coral reef ecosystems dynamics.