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NeMO-Net – The Neural Multi-Modal Observation & Training Network for Global Coral Reef Assessment

Ved Chirayath[1], Alan Sheng Xi Li[1], Juan Luis Torres-Perez[2], Michal Segal-Rosenhaimer[1], Sam Purkis[3] and Jarrett van den Bergh[1], (1)NASA Ames Research Center, Moffett Field, CA, United States, (2)NASA Ames Research Center, Earth Science Division, Moffett Field, CA, United States, (3)University of Miami, Marine Geosciences, Miami, United States

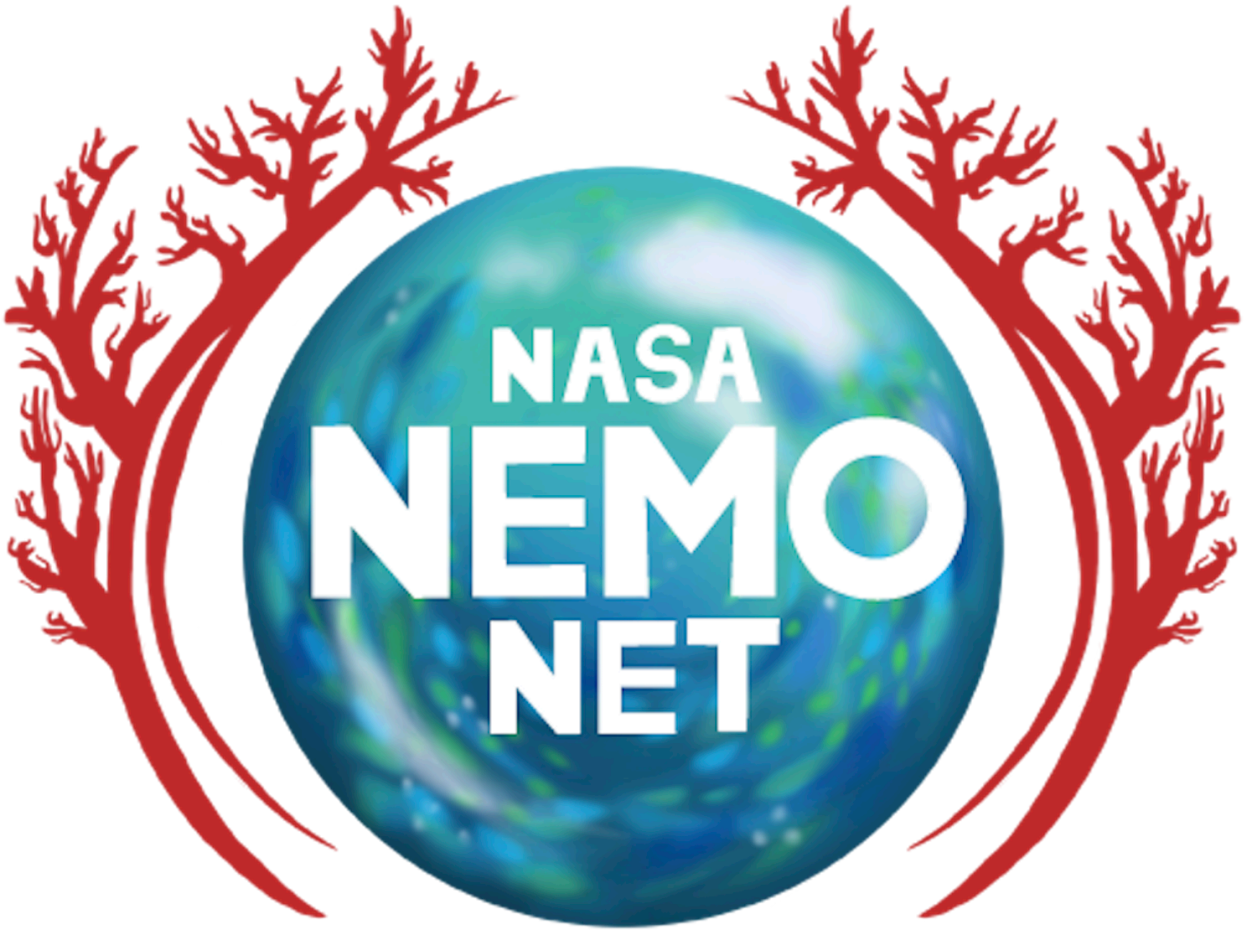
Abstract Text:

We present NeMO-Net, the first open-source deep convolutional neural network (CNN) and interactive learning and training software aimed at assessing the present and past dynamics of coral reef ecosystems through habitat mapping into 10 biological and physical classes. Shallow marine systems, particularly coral reefs, are under significant pressures due to climate change, ocean acidification, and other anthropogenic pressures, leading to rapid, often devastating changes, in these fragile and diverse ecosystems. Historically, remote sensing of shallow marine habitats has been limited to meter-scale imagery due to the optical effects of ocean wave distortion, refraction, and optical attenuation. NeMO-Net combines 3D cm-scale distortion-free imagery captured using NASA FluidCam and fluid lensing remote sensing technology with low resolution airborne and spaceborne datasets of varying spatial resolutions, spectral spaces, calibrations, and temporal cadence in a supercomputuer-based machine learning framework. NeMO-Net augments and improves the benthic habitat classification accuracy of low-resolution datasets across large geographic ad temporal scales using high-resolution training data from FluidCam.

NeMO-Net uses fully convolutional networks based upon ResNet and RefineNet to perform semantic segmentation of remote sensing imagery of shallow marine systems captured by drones, aircraft, and satellites, including WorldView and Sentinel. Deep Laplacian Pyramid Super-Resolution Networks (LapSRN) alongside Domain Adversarial Neural Networks (DANNs) are used to reconstruct high resolution information from low resolution imagery, and to recognize domain-invariant features across datasets from multiple platforms to achieve high classification accuracies, overcoming inter-sensor spatial, spectral and temporal variations.

Finally, we share our online active learning and citizen science platform, which allows users to provide interactive training data for NeMO-Net in 2D and 3D, integrated within a deep learning framework. We present results from the Pacific Islands including Fiji, Guam and Peros Banhos

where 24-class classification accuracy exceeds 91%.



Plain-Language Summary:
NeMO-Net is a single player game where players help NASA classify coral reefs by painting 3D and 2D images of coral. Players can rate the classifications of other players and level up in the food chain as they explore and classify coral reefs and other shallow marine environments and creatures from locations all over the world!

NeMO-Net is an opensource deep convolutional neural network (CNN) that leverages NASA's Supercomputer, Pleiades, to use game data to classify and assess the health of coral reefs around the world.

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. These data are used to train low resolution data from NASA's Earth Observing

System, including hyperspectral airborne remote sensing data and satellite data to determine coral reef ecosystem makeup globally at unprecedented spatial and temporal scales.

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ved.c@nasa.gov

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First Presenting Author
Presenting Author

Ved Chirayath
Primary Email: ved.c@nasa.gov

Affiliation(s):

NASA Ames Research Center
Moffett Field CA (United States)

Second Author

Alan Sheng Xi Li
Primary Email: alan.s.li@nasa.gov

Affiliation(s):

NASA Ames Research Center
Moffett Field CA (United States)

Third Author

Juan Luis Torres-Perez
Primary Email: juan.l.torresperez@nasa.gov

Affiliation(s):

NASA Ames Research Center
Earth Science Division
Moffett Field CA (United States)

Fourth Author

Michal Segal-Rosenhaimer
Primary Email: michal.segalrozenhaimer@nasa.gov

Affiliation(s):

NASA Ames Research Center
Moffett Field CA (United States)

Fifth Author

Sam Purkis
Primary Email: spurkis@rsmas.miami.edu

Affiliation(s):

University of Miami
Marine Geosciences
Miami (United States)

Sixth Author

Jarrett van den Bergh
Primary Email: jarrett.s.vandenbergh@nasa.gov

Affiliation(s):

NASA Ames Research Center
Moffett Field CA (United States)

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