Master thesis subject

Mapping Corals from above with machine learning.

Context

Coral reefs are suffering a worldwide decline due to the degradation of the marine environment. One of the main causes of this decline are the anomalous heat waves that provoke the death of hard skeleton corals, the cornerstone of the reef ecosystem. As the pace of climate change forecasts stressful conditions to become persistent around the world in the next decades, there is an urgent need in identifying coral populations that are more tolerant to thermal stress.

To this end, the seascape genomics approach can be used to investigate adaptation to the environment in coral populations. This approach is at the crossroads between oceanography and populations genomics.

To date, the seascape genomics approach relies on publicly available environmental datasets such as those made available by the Copernicus Marine Environment Monitoring System (CMEMS). Data from CMEMS combine remote sensing observations with in-situ records to provide a global scale characterization of ocean conditions (e.g. temperature, salinity, chlorophyll concertation). These products, however, were not conceived to study the biology of marine sessile organisms. One of the main limitations is spatial resolution, which is rarely available at a finer scale than 1 km. This is problematic because a seascape, especially in proximity to the coastline, can display fine-scale

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structures that can drive adaptive processes in coral populations. Without a higher resolution in the seascape characterization, these adaptive processes cannot be detected with the seascape genomics approach. This master project considers solutions for the issue of mapping corals from above with high resolution remote sensing.

In this project, the student will approach the question of high-resolution coral mapping from remote sensing data. Using Landsat 8 and Sentinel 2 satellite images, the presence and density of corals will be characterized with machine learning techniques. Approaches based on feature engineering as random forests and potentially convolutional neural networks (Krizhevsky et al., 2012) will be used for this purpose. The models will be trained on an existing set of coral density reports covering several oceanic regions, which will be matched to remote sensing images (https://www.catlinseaviewsurvey.com/). When trained, the machine learning model will be then deployed on a set of measurements in New Caledonia.

When deployed routinely, the developed system could be used to monitor the variation in the sea-bottom composition and evaluate, for instance, whether specific reefs are gaining or losing coral cover over time. Such information is fundamental, as it might enable to verify whether reefs exposed to recurrent thermal stress are less sensitive to future heat waves.

Objectives

- Gather a remote sensing image collection at the location of records of coral density worldwide
- Develop a machine learning model that predicts the presence of corals and their density from the corresponding satellite image patch
- Provide a map describing changes in coral covers over the last 5 years in the Southern Lagoon of New Caledonia.

Requirements and practical info

- Background in machine/deep learning is welcome.
- Programming skills in Python.
- The thesis will be supervised from the Sion campus.
- Access to parallel computing resources is provided.

Literature

- Krizhevsky, Alex, Ilya Sutskever, and Geoffrey E. Hinton. "Imagenet classification with deep convolutional neural networks." Advances in neural information processing systems. 2012.
- Antoine Collin, Jean Laporte, Benjamin Koetz, François-Régis Martin-Lauzer, Yves-Louis Desnos.Mapping bathymetry, habitat, and potential bleaching of coral reefs using Sentinel-2. 13th Interna-tional Coral Reef Symposium (ICRS 2016), Jun 2016, Honolulu, United States. pp.405-420. hal-01460593
- Oliver Selmoni, Estelle Rochat, Gael Lecellier, Veronique Berteaux-Lecellier, Stéphane Joost (2020). Seascape genomics as a new tool to empower coral reef conservation strategies: An example on north-western Pacific Acropora digitifera. Evolutionary Applications, 588228. https://doi.org/10.1111/eva.12944

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