A Computational Approach to Bio-optical Functional Group Classification of Phytoplankton in Inland Waters

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Inland waters are the vital components of our ecosystems and face various threats mainly from the climate crisis and eutrophication (Meerhoff et al., 2022). The current monitoring techniques for addressing these threats rely on point-based measurements and laboratory analyses. In order to understand the parameters that govern our inland waters, extensive real-time monitoring is required. This research project intends to address this need by utilizing hyperspectral images from satellites and developing computational techniques to monitor inland waters. Phytoplankton are microscopic, photosynthetic organisms that play a crucial role in ecological monitoring due to their significance in the global carbon cycle and their rapid response to environmental changes (Reynolds 2006). Some phytoplankton species produce hepato- or neurotoxins leading to a significant degradation in the water quality. It is complex to predict these occurrences; therefore, efficient detection is essential (Brooks et al., 2016).

In this research project, we collect water samples from inland water synchronized with a satellite flyover and perform laboratory experiments to extract ground truths on phytoplankton pigment composition and concentrations, species composition, and additional valuable insights. Further, we will develop a computational model for unmixing spectral endmembers and determine these characteristics from the spectroscopic measurements of water samples. The hyperspectral mixture can be categorized into linear and non-linear models with the latter being more relevant in inland waters due to the complex light interactions. Hyperspectral non-linear unmixing is a challenging ill-posed problem that can be addressed using deep learning techniques like supervised, semi-supervised, unsupervised, and Deep autoencoder Networks. The Deep autoencoder Networks are of particular interest because of their unsupervised or self-supervised nature, ensuring the availability of end member estimates without the requirement of additional training data (Wang et. al, 2019) and they don't rely on pure pixel assumption. This computation model will be adapted to extract the phytoplankton pigment composition and concentrations, species composition, and other relevant insights from the Hyperspectral satellite data in inland waters.

The expected result is to create a spectral library based on the inherent optical properties of the phytoplankton and develop computational methods to functionally classify phytoplankton, and effectively distinguish phytoplankton-related signals from background noise in hyperspectral satellite images of inland waters with diverse optical characteristics.

References

Brooks, B. W., et al. (2016). Are harmful algal blooms becoming the greatest inland water quality threat to public health and aquatic ecosystems?. Environ Toxicol Chem 35(1), 6-13.

Meerhoff, M., et al. (2022). Feedback between climate change and eutrophication: revisiting the allied attack concept and how to strike back. Inland Water, 1-18.

Reynolds, C. S. (2006). The ecology of phytoplankton. Cambridge University Press.

Wang M, et al. (2019) Nonlinear Unmixing of Hyperspectral Data via Deep Autoencoder Networks, in *IEEE Geoscience and Remote Sensing Letters*, vol. 16, no. 9, 1467-1471.