Ph.D. Thesis Subject

Compressed fusion of Sentinel 2 and 3 time series for marine observation

Scientific domain: Signal and Image Processing

Keywords: spectral-spatial-temporal fusion of remote sensing images, joint factorization, compressive learning

Supervisors: Cédric Jamet and Matthieu Puigt

1 Thesis subject

Coastal water quality monitoring on a large spatial and temporal scale is to comply with the EU Marine Strategy Framework Directive. Studying the temporal and spatial variation of ocean color, allowed by remote sensing, provides information on the concentration of chlorophyll-a, suspended matter and marine particles. Two European Sentinel-2 (S2) and Sentinel-3 (S3) satellites allow to observe the color of coastal waters on different time and spatial scales. S2 has the adequate spatial resolution (10 m) to observe changes in coastal waters which, by nature, have high variability, while S33 has the adequate temporal resolution (2 days). In addition, S33 observes the same area in more spectral bands than S2.

However, to better understand the complex phenomena that take place in the coastal marine environment, it is necessary that the data available combine:

- good spectral resolution to better analyze the biogeochemical environment (chlorophyll, suspended particles, etc.),
- good spatial resolution to better analyze the distribution phenomena of this environment which are much more complex in a coastal environment than in the open sea,
- a short period of acquisition of these images to identify phenomena that are very concentrated over time (phytoplankton blooms for example).

No satellite data, not even those from S2 or S3, currently allows these three constraints to be respected. The fusion of ocean color images from these two satellites should help improve our representation of coastal areas and their quality.

This thesis project aims to address these issues. To that end, we wish to propose spatio-spectro-temporal fusion methods of S2 and S3 images, based on randomized and frugal matrix or tensor decomposition methods. The images generated after fusion will combine the spatial resolution of S2 and the spectral and temporal resolutions of S3. The validity of the merged images will be analyzed via comparisons with data taken in situ, in coastal areas of interest (Eastern Channel, Guyana, Cambodia, Vietnam).

2 Work Program and Tentative Timetable

Task	Duration	Period
Bibliography	6 months	From Month-1 to Month-30
Development of Novel S2-S3 Spectral-Spatial-Temporal Fusion Approaches	12 months	From Month-3 to Month-33
Application of these Approaches on Areas of Interest	9 months	From Month-18 to Month-33
Comparison with *In-situ* Data	3 months	From Month-18 to Month-34
Writing Conference Proceedings and Journal Articles	3 months	From Month-12 to Month-34
Ph.D. Thesis Writing	3 months	From Month-30 to Month-36
Total	**36 months**	**From Month-1 to Month-36**

3 List of 10 publications linked with the subject

1. Loncan, L., et al. (2015). Hyperspectral pansharpening: A review. Geosci. Remote Sens. Mag., 3(3), 27-46.
2. Yokoya, N. et al. (2017). Hyperspectral and multispectral data fusion: A comparative review of the recent literature. Geosci. Remote Sens. Mag., 5(2), 29-56.
3. Li, J. et al. (2020). Spatio-temporal fusion for remote sensing data: An overview and new benchmark. Science China Information Sciences, 63, 1-17.
4. Wang, M. et al. (2023). Tensor decompositions for hyperspectral data processing in remote sensing: A comprehensive review. Geosci. Remote Sens. Mag.
5. Alboody, A. et al. (2021, March). Experimental comparison of multi-sharpening methods applied to Sentinel-2 MSI and Sentinel-3 OLCI images. In Proc. IEEE WHISPERS'21.
6. Cissé, C. T. et al. (2022, May). A new deep learning method for multispectral image time series completion using hyperspectral data. In Proc. IEEE ICASSP'22 (pp. 1546-1550).
7. Hadir, A. et al. (2023, August). Réseau antagoniste génératif pour la fusion spatio-temporelle d'images satellitaires multi-spectrales. In Proc. GRETSI'23.
8. Mahoney, M. W. (2011). Randomized algorithms for matrices and data. Foundations and Trends in Machine Learning, 3(2), 123-224.
9. Yahaya, F. et al. (2023). A Framework for Compressed Weighted Nonnegative Matrix Factorization. Submitted to IEEE Trans. Signal Process.
10. Yahaya, F., et al. (2021, June). Random projection streams for (weighted) nonnegative matrix factorization. In Proc. ICASSP 2021 (pp. 3280-3284).

4 To apply

Please first send an e-mail to ({`cedric.jamet;matthieu.puigt`}`@univ-littoral.fr`) while attaching the documents that can support your application:

- your resume;
- a cover letter;
- your transcripts for the last year of B.Sc, the first year of M.Sc, and the last year of M.Sc (if the latter is available);
- A reference letter from the person in charge of your M.Sc degree.

Applications must be done online on both websites **(deadline: March 15th 2024, Midnight Paris time)**:

1. `https://recrutement.cnes.fr/fr/annonce/2699725-24-075-compressed-fusion-of-sentinel-2-and-`
2. `https://adum.fr/as/ed/voirproposition.pl?site=adumR&matricule_prop=53213#version`