PhD Position: Monitoring of multi-annual vegetation dynamics by high spatial resolution multi-source satellite time series

Multi-source Trend Filtering

Mathieu Fauvel, CR INRAe, Eric Ceschia, DR INRAe

CESBIO, Université de Toulouse, CNES/CNRS/IRD/UPS/INRAE, Toulouse, France

Context

In a context of global change, the multi-annual study of vegetation cycles in agricultural landscape is of great importance to quantify the adaptation and resilience of ecosystems over the years. With the advent of the Copernicus Sentinel-1&-2 missions, satellite remote sensing has made possible fine monitoring these ecosystems dynamics since 2016. The figure 1 shows two Sentinel-2 acquisitions at different dates, where changes in vegetation state are visible for crop parcels.

However, the analysis of these satellite images time series is difficult because of the large data volume (several To for one year of acquisition) and the multivariate nature of the spectral and temporal dimension. To be useful to thematic application, and in order to derive maximum application benefit, it is necessary to develop automatic methods for their analysis.

PhD Objectives

The objective of this PhD is to develop statistical learning models for monitoring the multiannual dynamics of vegetation. This monitoring will include the various intra-annual phenological cycles as well as their evolution over several successive years. It is planned to jointly use massive optical (e.g. Sentinel-2) and radar (e.g. Sentinel-1) satellite time series.

The statistical framework considered for this PhD is *trend filtering* [RT16]. This framework involves convex optimization problem with good scalability properties (parallelization and parsimony in particular). Early work has provided good results for a vegetation index. It possible in particular to manage irregularly and non-aligned time series. The PhD should lead to the development of computer tools allowing to characterize on a large scale the variables useful to the models used in landscape ecology. For this, two types of results are expected.

May 15, 2018 October 15, 2018

Figure 1: Sentinel 2 acquisitions over the south of Toulouse in 2018.

1. From a methodological viewpoint, the first objective of the thesis will be to obtain theoretical results on the construction of efficient trend filtering models adapted to multi-source time series at high spatial resolution. The starting point will be to extend the formulation to the case of multi-source data [KKBG09]. A second extension, will be to consider data with different spatial resolution [FDC20].
2. The second objective of the thesis will be to evaluate the performance of the algorithm for monitoring the vegetation cycles of different environments (grasslands and crops in particular) in metropolitan France. The PhD will benefit from field measurements on the CESBIO's South-West Regional Satellite Observatory (OSR SO). The production of a cartographic prototype of vegetation cycles via the CES Theia *Variables for Biodiversity* will be considered too.

Application

Requirements The candidate must have a solid background at least in one of the following items

- Statistical signal and image processing,
- Machine learning,
- Optimization.

A good knowledge of English and scientific programming (Python, C/C++) is required.

Contact Candidates should send an e-mail to mathieu.fauvel@inrae.fr and eric.ceschia@inrae.fr containing:

- Full CV,
- Motivation letter,
- Contact information for 2 references, and/or recommandation letter if possible.

Application is open until May 12, 2023.

The PhD grant is provided by the SDUEE doctoral school (Geosciences, Astrophysics, Space and Environmental Sciences). Details for the full application is given here:

`https://adum.fr/as/ed/page.pl?site=sdu2e&page=candidater`.

Practical details

The PhD grant is about 1700 € per month, for 36 months. Possibility to give lectures/labworks with payoff. The recruit will be located in the CESBIO lab, in Toulouse and will interact with people involved in the project. French is not mandatory.

CESBIO Research at CESBIO aims to develop knowledge on continental biosphere dynamics and func- tioning at various temporal and spatial scales and as such participates in the specification of space missions and the processing of remotely sensed data. CESBIO is or has been PI for 2 ESA satellite missions (SMOS, the Soil Moisture and Ocean Salinity satellite, and BIOMASS, a P-band SAR system to be launched in 2020) and for the French-Israeli Venus satellite (2-day revisit, 10 m resolution, optical sensor for vegetation monitoring, launched in 2017).

CESBIO has developed the IOTA2 processing chain for the operational production of land-cover maps at the national French scale. It has therefore a strong experience in upscaling learning and classification processes. CESBIO has been committed over the last two years in collecting feed- back, tailoring IOTA2 outputs for various end-users, and disseminating it for several research institutes in France. The CES OSO is producted using IOTA2.

References

[FDC20] Vinicius Ferraris, Nicolas Dobigeon, and Marie Chabert. Robust fusion algorithms for unsupervised change detection between multi-band optical images — a comprehensive case study. *Information Fusion*, 64:293–317, 2020.

[KKBG09] Seung-Jean Kim, Kwangmoo Koh, Stephen Boyd, and Dimitry Gorinevsky. L1 trend filtering. *SIAM Review*, 51(2):339–360, 2009.

[RT16] Aaditya Ramdas and Ryan J. Tibshirani. Fast and flexible ADMM algorithms for trend filtering. *Journal of Computational and Graphical Statistics*, 25(3):839–858, 2016.