

Multiband image fusion for astrophysics

– M.Sc. proposal in signal/image processing –

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Abstract

Recently developed astronomical data fusion methods combine the benefits of multispectral and hyperspectral images to enhance scientific interpretation of the data. Multispectral images have a high angular (spatial) resolution but are composed of few spectral bands, while hyperspectral images contain very detailed spectra (up to a few thousands spectral points) but measured at lower spatial resolution. The fused product, combining those images, reconstructs the observed scene at high spatial *and* spectral resolutions. The approach described in those papers consists in formulating an observation forward model of an imager and a spectrometer, providing respectively multispectral and hyperspectral images. Several conventional penalization have been considered, e.g., based on Sobolev regularization or sparse representation over a dictionary.

The main objective of this internship is to extend these methods to more sophisticated data-driven regularizations. In particular, a particular attention will be paid to so-called deep priors and related approaches.

The performance of the developed methods will be assessed through experiments conducted on simulated data sets or real images provided by ground (e.g., MUSE) and space (e.g., JWST and HST) observatories dedicated to astronomical observations.

Keywords

Inverse problems, deep learning, optimization, spectral imaging, astrophysics.

Scientific environment

This M.Sc. trainee period will be part of a longstanding collaboration between the “Systèmes décisionnels” (DISC) group from ISAE-Supaéro, the “Signal & Communications” (SC) group from IRIT (CNRS and Toulouse INP) and the “Milieu Interstellaire, Cycle de la Matière, Astro-Chimie” (MICMAC) group from IRAP (CNRS, CNES and University of Toulouse). The SC and DISC groups bring their expertise in the development of state-of-the-art signal & image processing methods, in particular for multivalued images for various applications (medical imaging, remote sensing, microscopy). The MICMAC group will bring its expertise on astronomy and astrophysics, in particular in the context of analyzing interstellar matter. Besides, the [Early Release Program](#) (ERS 1288) led by Dr. Olivier Berné will favor an easy access to the instrument specifications, as well as privileged interactions with instrument designers.

The M.Sc. student will therefore benefit from a favorable context and will be able to rely on the most recent results and advances in signal & image processing for astronomical data. He/she will be mainly co-advised by

- [Thomas Oberlin](#), Assistant Professor within the [DISC](#) group at [ISAE-Supaéro](#)
- [Nicolas Dobigeon](#), Professor within the [SC](#) group at [IRIT](#) laboratory (UMR CNRS 5505, Toulouse)
- [Olivier Berné](#), CNRS Researcher within the [MICMAC](#) group at [IRAP](#) (UMR CNRS 5277, Toulouse)

and with a possible collaboration with

- [Thierry Contini](#), CNRS Researcher within the [GAHEC](#) group at [IRAP](#) (UMR CNRS 5277, Toulouse)

Period and continuation as a Ph.D. thesis

This internship shall take place in 2022. The precise starting and ending dates can be adjusted according to the availability of the selected candidate.

A **Ph.D. position** will be considered as a possible continuation of this M.Sc. training period.

Profile & requirements

Master or Engineering school students with major in applied mathematics, computer science or electrical engineering.

The knowledge needed for this work includes a strong background in **signal & image processing** and/or **machine learning**. Experience and/or interests in **astrophysics** will be appreciated.

Contact & application procedure

Applicants are also invited to send (as pdf files)

- a detailed curriculum,
- official transcripts from each institution you have attended (in French or English).

to the co-advisors

- Thomas Oberlin, thomas.oberlin@isae-superaero.fr
- Nicolas Dobigeon, nicolas.dobigeon@irit.fr
- Olivier Berné, olivier.berne@irap.omp.eu

You will be contacted if your profile meets the expectations. Review of applications will be closed when the position is filled.

References

- [1] C. Guilloreau, Th. Oberlin, O. Berné, É. Habart and N. Dobigeon, “Simulated JWST datasets for multispectral and hyperspectral image fusion,” *The Astronomical Journal*, vol. 160, no. 1, June 2020.
- [2] C. Guilloreau, Th. Oberlin, O. Berné and N. Dobigeon, “Hyperspectral and multispectral image fusion under spectrally varying spatial blurs – Application to high dimensional infrared astronomical imaging,” *IEEE Trans. Computational Imaging*, vol. 6, pp. 1362-1374, Sept. 2020.