Sparse unmixing for active molecular imaging

– M.Sc. (M2 or final year engineering project) proposal in signal/image processing
(with possible continuation as fully funded Ph.D. position) –

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Abstract

The capabilities of spectral imaging are certainly attractive in many applications since they offer the opportunity to address complex physical/chemical questions. However, interpreting the resulting images requires a "dual" lens to extract the relevant information encoded in both spatial and spectral domains. While spatial information can be fully exploited through image processing techniques, this M.Sc. project aims at providing a meaningful spectral decomposition of the imaging data. This will be achieved by analyzing the reduced spectral data set provided by sparse, targeted sampling, based on the rationale that information is typically highly redundant across channels when using any kind of spectral imaging. Such a redundancy is inherent to the nature of the measurement, i.e. the bandwidth of the molecular spectroscopy signals, and introduces high correlations among spectral channels. More importantly, the spectral variation observed in the imaged sample is likely to be attributed to a limited number of sources (individual components), which allows a whole set of high-dimensional measurements to be modeled with a small number of degrees-of-freedom, i.e. to lie in a low-dimensional subspace. We propose to leverage the later property to reach two levels of characterization, namely signal subspace learning and spectral unmixing. The main objective of this M.Sc. project is to design subspace learning and/or spectral unmixing methods dedicated to sparsely sampled images, i.e., from partial and targeted measurements provided by our proposed IMAGIN acquisition protocol.

Keywords

Signal processing, image processing, multi-band imaging.

Scientific environment

This M.Sc. trainee period will be part of the IMAGIN project, funded by ANR. The two main teams involved are the "Signal & Communications" (SC) group from IRIT (CNRS and Toulouse INP) and the "Dynamics, Nanoscopy & Chemometrics" (DyNaChem) group from LASIRE (CNRS and University of Lille). The SC group brings its expertise in the development of state-of-the-art signal & image processing methods, in particular for multivariate images for various applications (medical imaging, remote sensing, microscopy). The DyNaChem group is interested in micro- and nano-imaging of photoactive bio-systems, with a particular focus on hyperspectral and super-resolved nanometer-scale imaging of ultrafast processes, and on the development of new instrumentation and methodologies for the analysis of these hyperspectral and super-resolved data.

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 molecular imaging. He/she will be mainly co-advised by

— Henrique Goulart, Assistant Professor within the SC group at IRIT laboratory (UMR CNRS 5505, Toulouse)

— Nicolas Dobigeon, Professor within the SC group at IRIT laboratory (UMR CNRS 5505, Toulouse)

in collaboration with

— Cyril Ruckebusch, Professor within the DyNaChem group at LASIRE laboratory (UMR CNRS 8516, Villeneuve d'Ascq)

The physical location for the project is the INP-ENSEEIHT campus (Signal & Communications group), in a lively neighbourhood of the Toulouse city center.

Funding

Fully funded by ANR, this M.Sc. position is part of the IMAGIN project. A **fully funded Ph.D. position** is available for a possible continuation of this M.Sc. training period.

Period

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

Profile & requirements

Master 2 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** (statistics, linear algebra, optimization). Experience and/or interests in **microscopy** 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
- Henrique Goulart, henrique.goulart@irit.fr
- Nicolas Dobigeon, nicolas.dobigeon@irit.fr
- Cyril Ruckebusch, cyril.ruckebusch@univ-lille.fr

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

References

[1] E. Monier, Th. Oberlin, N. Brun, X. Li, M. Tencé and N. Dobigeon, "Fast reconstruction of atomic-scale STEM-EELS images from sparse sampling," *Ultramicroscopy*, vol. 2020, no. 112993, Aug. 2020.

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