

Computational Raman Imaging

MSc Project, CREATIS, Lyon, France

The [CREATIS laboratory](#) announce the opening of a MSc Project starting in March 2027.

Keywords Computational Optics, Raman Imaging, Hyperspectral Imaging, Image Reconstruction,.

General context Raman imaging allows the identification of the different molecules that are present in a sample. To do so, a Raman microscope measure a hyperspectral (x, y, λ) -image that indicate the presence of photons whose wavelength is shifted from that of the excitation. However, the acquisition of hyperspectral images using 1D or 2D arrays of sensors imposes a physical measurement limitation, resulting in a trade-off between the total acquisition time and the spatial or spectral resolution of the hypercube. The lower the spatial or spectral resolution, the longer the acquisition time.

The internship is funded by the SMARS ANR Project, which aims to develop methods that will reduce the time required to complete a successful Raman micro-imaging experiment by one to several orders of magnitude. SMARS is a collaborative project between [HORIBA](#), a world leader in the field of high-end Raman spectroscopy, and two academic research laboratories, [CREATIS](#) (Lyon) and [LASIRE](#) (Lille). A PhD position on the same topic will be available in October 2027.

Computational spectral acquisitions CREATIS has developed expertise in hyperspectral computational imaging techniques [1], which typically measures

$$\mathbf{M}_\lambda \sim \mathcal{D}(\mathbf{H}\mathbf{F}_\lambda) \quad , 1 \leq \lambda \leq \Lambda, \quad (1)$$

where $\mathbf{H} \in \mathbb{R}^{K \times N_x}$ represents the measurement matrix that concatenates the K spatial light profiles used for acquisition, $\mathbf{F}_\lambda \in \mathbb{R}^{N_x \times N_y}$ is a λ -slice of the full hypercube $\mathbf{F} \in \mathbb{R}^{N_x \times N_y \times \Lambda}$, and $\mathcal{D}$ represents the distribution of measurement errors, typically centered on $\mathbf{H}\mathbf{F}_\lambda$. Usual noise models are Poisson and Gaussian noise. In practice, such measurements can be taken with a system based on a digital a spatial light modulator and a spectrograph. The different rows of $\mathbf{H}$ are uploaded sequentially onto the spatial light modulator, and the spectrograph measures one row of $\mathbf{M}_\lambda$ at a time for all λ 's in parallel.

Objective of the Project Our objective is to achieve fast Raman imaging by exploiting the concept of computational hyperspectral imaging. Unlike [2, 3, 4] that proposed systems that operate in the spectral domain, our approach will work in the spatial domain by moving the sample during the acquisition. The project will address the following challenges:

- **Forward model** — We need to establish a forward model that predicts the measurements given the hypercube, in a manner similar to Eq. (1). This requires careful mathematical modelling to match actual acquisitions. Our model should includes movement of the sample during acquisition, the energy delivered to the sample, and the noise levels.
- **Design of the measurement matrix** — Finding a good matrix $\mathbf{H}$ is an open mathematical problem. The design of the measurement profiles (i.e., the rows of $\mathbf{H}$) is restricted by physical limitations, which makes the problem more challenging.
- **Reconstruction** — The hypercube $\mathbf{F}$ needs to be estimated from the measurements $\mathbf{M}$. The sparse nature of Raman spectra with small support calls for the reworking of the reconstruction algorithms commonly adopted in hyperspectral computational imaging.

Skills We are looking for an enthusiastic and autonomous candidate with a strong background in applied mathematics (statistics and optimisation), signal and image processing, and machine learning. A solid background in optics would be highly valued, both for the modelling part of the project and for any potential continuation in a PhD programme.

The applicant can be enrolled in either a Master's or an Engineering degree programme.

How to apply? Please send a curriculum, a motivation letter, and your academic records before **January 1st 2027** to nicolas.ducros@creatis.insa-lyon.fr, jeremy.cohen@cnrs.fr and mahieu@creatis.insa-lyon.fr

References

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