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A learning Raman microscope for high-speed imaging: the compressive Raman concept

Raman imaging is recognized as a powerful label-free approach to provide contrasts based on chemical selectivity. Nevertheless, Raman-based microspectroscopy still have several drawbacks related to its 3D hyperspectral data format and throughput that will soon be bottlenecks when pushing this technology to clinical biomedical and industrial applications scenarios.

Compressive sensing has shown a paradigm shift approach where one can obtain accurate information from fewer samples than assumed by Nyquist-Shannon sampling theorem. A key concept in compressive sensing is to recognize that data sparsity can be exploited to computationally reconstruct data that has been undersampled. Such approach opens interesting perspectives not only to compress data sets during its acquisition, but also to concomitantly speed up the imaging process as less data is needed to obtain useful information.

In this contribution, I will introduce the concept of compressive Raman imaging: by exploiting sparsity [1] and redundancy [2] in Raman data sets, one can considerably simplify and speed up the spectral image acquisition, nowadays reaching high-speed imaging [3]. I will discuss the different ways of performing compressive Raman, in particular focusing on challenges for bio-imaging, and how we recently tackled them. With these outcomes, compressive Raman imaging soon may be routinely used by non-specialists of vibrational spectroscopy: that is, in a “blind” manner, due to the simpler workflow provided by the compressive Raman imaging framework.

References

[1] Sturm *et al*, ACS Photon. 6, 1409 (2019); Scotte *et al*. Anal. Chem. 90, 7197 (2018).
[2] Soldevila *et al*, Optica 6, 341 (2019).
[3] Gentner *et al*, arXiv:2301.07709 (2023).

Figures

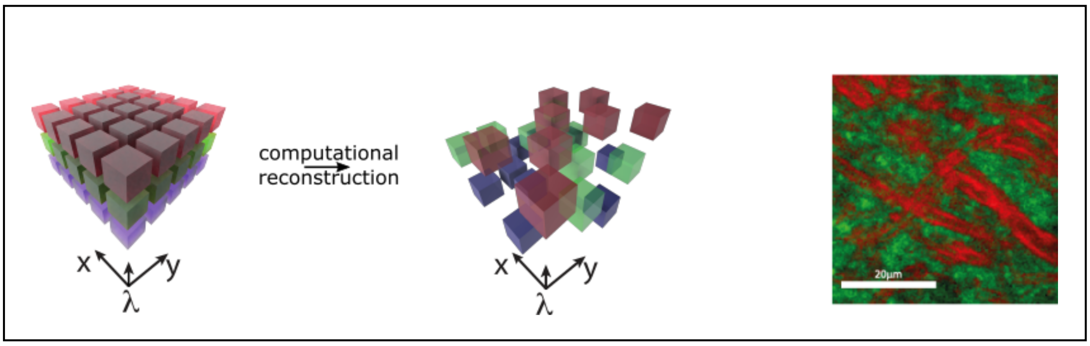

Figure 1: (left-center panel) Conceptional description of the compressive Raman framework, where the hyperspectrum is sparsely sampled and the information is reconstructed aided by advanced algorithms. (right panel) one example of biological application of this technology: lipid-rich (red) and protein-rich (green) chemical images of brain tissue.