A Hardware Implementation of a Deep Image Reconstruction Method

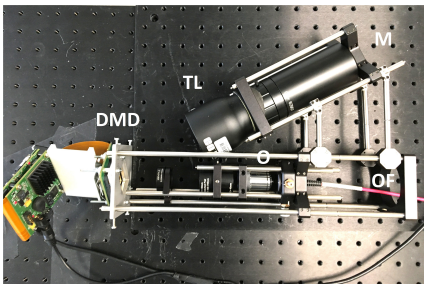
Master Project (Lyon, France)

The **CREATIS laboratory** announces the opening of a six-month internship position, starting in March 2021. The goal of this project is to implement the acquisition and reconstruction software of a hyperspectral imaging device designed to guide the surgeon during neurosurgery.

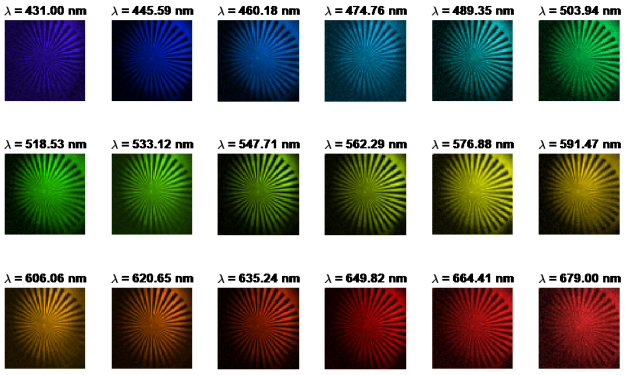
Keywords Image acquisition, image reconstruction, deep learning, computational optics, single-pixel imaging, Python, medical imaging, neurosurgery.

Background Our group is particularly interested in the development of computational imaging systems that combine advances in hardware and software [1]. In particular, compressive imaging is a paradigm that enables two-dimensional imaging from a point detector. This leads to high-performance optical imaging systems (e.g., hyperspectral and/or time-of-flight measurements) at relatively low cost, thus raising interest in academia and industry [2, 3]. We aim to develop a fast compressive camera for fluorescence-guided neurosurgery. Fluorescence-guided surgery is an imaging technique that helps surgeons to perform safer and less-invasive surgery. While quantitative fluorescence imaging needs to exploit the full spectrum, there are no traditional hyperspectral cameras with sufficient spectral resolution.

We have developed a in-house hyperspectral imaging device that is composed of a digital micromirror device and a spectrometer [4]. The spectrometer acquires a set of spectra for a predetermined sequence of light patterns that are loaded onto the digital micromirror device. Then, the raw spectra are fed into a deep network to reconstruct the hyperspectral cube that corresponds to the scene. In a series of work, we have proposed different deep network architectures [5, 6, 7]. Such networks have been successfully applied to the experimental data acquired by our hyperspectral imaging device [6, 8].



(a) Picture of our hyperspectral device (DMD: digital micromirror device, TL: telecentric lens, OF: optical fiber toward the spectrophotometer, O: objective, M: towards microscope or sample).



(b) Hypercube acquired and reconstructed in the range $[431-679]$ nm. The sample was the star sector resolution target.

Project The goal of this project is to implement a new acquisition and reconstruction software for our hyperspectral device. The successful candidate will have access to our hyperspectral imaging device that can be coupled to a surgery microscope. The in-house hyperspectral imaging device is composed of a digital micromirror device and a spectrometer. The spectrometer acquires a set of spectra for a predetermined sequence of light patterns that are loaded onto the digital micromirror device. Then, the raw spectra are fed into a deep network to reconstruct the hyperspectral cube that corresponds to the scene. The acquisition is currently implemented in Matlab/Labview, while the reconstruction is implemented in Python but it requires to load the raw data from the hard disk.

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The goal of the project is to fully control our instrumentation using Python, which should enable real time reconstruction using deep learning methods. The two main tasks of the project are:

- The conversion into Python of the existing acquisition software implemented in Matlab/Labview.
- The implementation of different deep learning methods that can reconstruct images in real time.

The successful candidate is expected to contribute to two in-house Python toolboxes –one for image acquisition, the other one for image reconstruction. He/She will work in close collaboration with a PhD student –for the theoretical aspects of deep image reconstruction– together with an Engineer in optical instrumentation, and will have access to an experimental acquisition device.

Skills We are looking for an enthusiastic and autonomous candidate with a strong background in instrumentation control, image processing, or deep learning. The applicant can be enrolled in either a Master or Engineering degree program. Strong programming skills in Python are required.

How to apply? Send CV, motivation letter, and academic records to nicolas.ducros@creatis.insa-lyon.fr

Salary ∼€550 net monthly.

References

[1] https://www.creatis.insa-lyon.fr/~ducros/WebPage/single_pixel_imaging.html.

[2] F. Rousset, *Single-Pixel Imaging : Development and applications of adaptative methods*. PhD thesis, Institut National des Sciences Appliquées de Lyon, Politecnico di Milano, 2017.

[3] X. Miao and B. Amirparviz, "Single pixel camera." Google LLC, US Patent US9071739B2, 2015.

[4] F. Rousset, N. Ducros, F. Peyrin, G. Valentini, C. D'Andrea, and A. Farina, "Time-resolved multispectral imaging based on an adaptive single-pixel camera," *Opt. Express*, vol. 26, pp. 10550–10558, Apr 2018.

[5] N. Ducros, A. L. Mur, and F. Peyrin, "A completion network for reconstruction from compressed acquisition," in *2020 IEEE 17th International Symposium on Biomedical Imaging (ISBI)*, pp. 619–623, 2020.

[6] A. Lorente Mur, F. Peyrin, and N. Ducros, "A Deep Network for Reconstructing Images from Undersampled Poisson data." working paper or preprint, Sept. 2020.

[7] A. Lorente Mur, P. Bataille, F. Peyrin, and N. Ducros, "Deep Expectation-Maximization for Image Reconstruction from Under-Sampled Poisson Data." working paper or preprint, Oct. 2020.

[8] A. L. Mur, B. Montcel, F. Peyrin, and N. Ducros, "Deep neural networks for single-pixel compressive video reconstruction," in *Unconventional Optical Imaging II* (C. Fournier, M. P. Georges, and G. Popescu, eds.), vol. 11351, pp. 71 – 80, International Society for Optics and Photonics, SPIE, 2020.