CREATIS

PROJET FINANCÉ PAR L'ANR · PROJECT FUNDED BY THE ANR · ANR

UNIVERSITÉ DE LYON

Fast computational hyperspectral imaging

Post doctoral fellowship / Engineer position (Lyon, France)

Objective We are actively seeking a postdoctoral fellow or an engineer to spearhead the development of a high-speed computational imaging system tailored for hyperspectral imaging. This cutting-edge camera need to be developed to detect Protoporphyrin fluorescence signal, specifically in the context of glioma resection. The role, funded by ANR, will encompass the full spectrum of responsibilities, from conceptualization of an optical experimental setup, its characterization, the acquisition of hypercubes from *ex-vivo* and *in-vivo* glioma and the post-procesing of theses hypercubes.

Keywords Hyperspectral imaging, spectrometer, Python, fluorescence, single-pixel imaging, glioma.

Background Our research group is dedicated to advancing computational imaging systems that harness the synergy of hardware and software innovations [1, 2], with a specific focus on acquiring hyperspectral data cubes characterized by two spatial dimensions and one spectral dimension. To this end, we've developed an in-house hyperspectral imaging setup (as depicted in Figure 1a) comprised of a digital micromirror device (DMD), a spectrometer, and a camera. In this setup, the spectrometer captures a series of spectra associated with predefined light patterns loaded onto the DMD, allowing us to reconstruct the hyperspectral data cube.

Our main goal is to optimise glioma resection in order to increase the life expectancy of patients. Currently, glioma removal involves surgery to open the cranial cavity and remove the tumour. During this operation, neurosurgeons use a fluorescence microscope to observe the emission of Protoporphyrin IX (PpIX), a fluorophore selectively present in tumour cells. However, the current fluorescence microscope can only provide information about the total fluorescence intensity.

Our research team has demonstrated that by exploiting the full PpIX spectrum present in gliomas, it is possible to distinguish the boundaries between tumour tissue and healthy tissue [3]. Consequently, our initial setup is transported to the operating theatre of the neurosurgical block, allowing us to acquire hyperspectral data cubes from biopsies taken during surgery (as shown in Figure 1b). These biopsies have different spectral characteristics at different locations, allowing us to pinpoint the boundary between healthy and tumour cells. This innovative approach holds great promise for improving the precision and effectiveness of glioma resection.

Challenge Currently, the total acquisition time is suitable for biopsy samples but impractical for in vivo imaging. In response, our group has developed compressive imaging strategies aimed at reducing the number of patterns required for acquisition, thereby reducing the total acquisition time. While this is a significant advance, it is still insufficient for clinical in vivo applications. Hardware development is needed to increase speed by developing a second experimental setup.

The main tasks of the project include:

- Take over and improve the existing optical setup
- The development of the second optical setup
- Development of the instrument control software (based on the SPAS package [4])
- Use of reconstruction algorithms based on deep learning (based on the Spyrit package [5])
- Characterisation of the imaging device (e.g. sensitivity, spatial and spectral resolution)
- Acquisition at the hospital and post-processing

Project details The project comprises two main concurrent tasks:

- **Optical Setup Improvement and Biopsy Imaging:** The first task is to take the existing optical setup and make improvements, both software and hardware, where necessary. The upgraded setup will be used to acquire hyperspectral data cubes from biopsies within the hospital's operating