Internship project: Spectral filter for hyperspectral microscopy

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1 Introduction

Some background information on the problem, as well as relevant starting-point references, are provided below.

1.1 Hyperspectral imaging/microscopy

Hyperspectral imaging (HSI) refers to imaging of a sample at multiple spectral bands or wavelengths [1]. This has been applied to a wide array of fields including food quality control, forensic sciences, archaeology, and biomedical sciences. In biomedical applications, HSI allows probing of optical properties such as absorption, scattering and fluorescence, which are expected to differ between different types of tissue. In microscopy, this can help highlight certain features or classify tissues based on their spectral signature, as illustrated in Fig. 1.

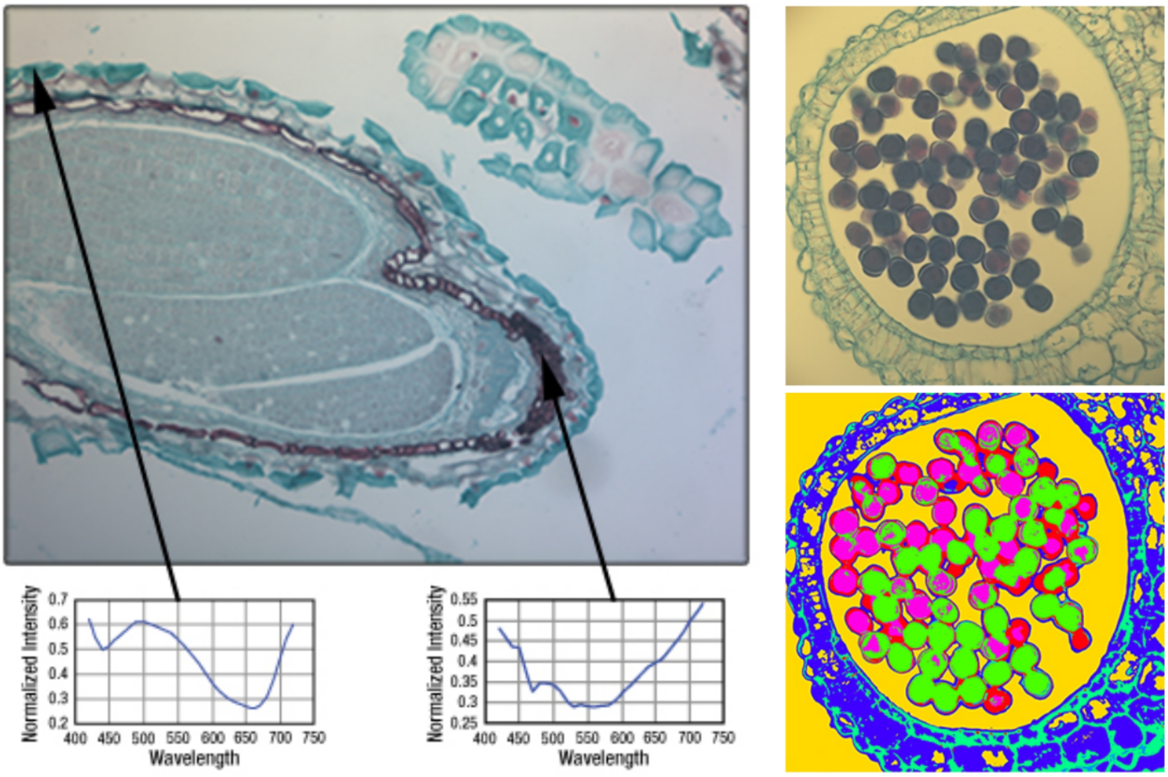

Figure 1: (Left) A color image of the mature capsella bursa-pastoris embryo, with two different spectra highlighted in different parts of the image. (Right, top) True color image of a Brassica flower bud cross section. (Right, bottom) false color image of the same bud after spectral classification. Images reproduced from Thorlabs webiste [2].

There exist many different methods to obtain hyperspectral images. In microscopy, this can be done in the transmission and reflection modes, with different spectral or spatial scannig methods (e.g. point-scanning, wavelength-scanning, snapshot imaging, etc.). For each of these methods, there exist several technologies, each having benefits and disadvantages in terms of spectral range and bandwidth, transmission efficiency, complexity, tuning speed and cost. These characteristics are important as they often determine the potential applications of HSI systems.

2 Proposed Work

In this project, the student will be asked to develop a compact and cost-effective continuously-tunable wavelength filter inspired by previously published results [3, 4]. These designs will be adapted for the visible range and use a novel fiber optic component called a wideband multimode circulator. The student will first validate the theoretical model for the device. Then they will assemble and characterize its performance and compare experimental results to theoretical values. Finally, the filter will be adapted to work with a commercial microscope to perform hyperspectral imaging on histology slides.

3 Requirements & learning outcome

We are looking for a Bachelors/Masters student with knowledge of physics and engineering and an affinity for hands on experimental work. Some experience in programming (Matlab, Python, etc.) is necessary for data analysis. Experience with Labview for system prototyping is beneficial. The student will gain experience in optics, experimental design, and HSI data anslysis. They will also develop skills in collaboration, scientific writing, and presenting. The expected duration of the internship is three months, but can be adapted based on student needs.

References

[1] G. Lu and B. Fei, "Medical hyperspectral imaging: a review," *Journal of biomedical optics*, vol. 19, no. 1, pp. 010901–010901, 2014.

[2] Thorlabs, "Hyperspectral imaging system." `https://www.thorlabs.com/newgrouppage9.cfm?objectgroup_id=11095` [Online; accessed 17-May-2023].

[3] S.-H. Yun, C. Boudoux, G. J. Tearney, and B. E. Bouma, "High-speed wavelength-swept semiconductor laser with a polygon-scanner-based wavelength filter," *Optics letters*, vol. 28, no. 20, pp. 1981–1983, 2003.

[4] X. Attendu, C. Crunelle, M. P. de Sivry-Houle, B. Maubois, J. Urbain, C. Turrell, M. Strupler, N. Godbout, and C. Boudoux, "Towards combined optical coherence tomography and hyper-spectral imaging for gastrointestinal endoscopy," in *Multimodal Biomedical Imaging XIII*, vol. 10487, pp. 7–14, SPIE, 2018.