Master 1 Internship

Computational super-resolution with deep learning for fluorescence microscopy

Fluorescence microscopy is one of the most important imaging techniques to observe and decipher complex cellular mechanisms. The category of super-resolution microscopy regroups modalities that are able go beyond the physical limits of traditional optical microscopes, and several striking advances in recent years have provided access to cellular structures with unprecedented resolution [2]. However this comes at the price of downsides: super-resolution microscopes usually involves exposure to high intensity light that can damage the samples, long acquisition time, and they induce difficulties for calibration and sample preparation. In particular, it is usually necessary to find a tradeoff between spatial and temporal resolution to maintain a reasonable level of photo-toxicity. This issue has been a major limitation to link the cellular structures observed with high accuracy with their role in the dynamic cell processes.

In parallel, computational super-resolution based on deep learning has been developing rapidly in the field of computer vision for various applications [3]. The principle is to reproduce a super-resolution effect by learning the transfer from low resolution (LR) to high resolution (HR) images of the same scene. This approach requires a set of training LR and HR image pairs that should be acquired in the same conditions and be perfectly registered. Motivated by the success of these methods, there has been a recent interest to adapt them in microscopy [4, 1]. The training image pairs can be obtained from the same modality with different settings, or from two different modalities to generate super-resolution images from conventional LR images.

The goal of this internship is to leverage computational super-resolution methods to improve the temporal resolution in microscopy image sequences. The project will focus on the analysis of the centriole, which is a large multi-protein complex that plays a fundamental role in cellular processes such as spindle assembly or fluid motion. We have at our disposal a large dataset of images of centrioles in different modalities, including super-resolution and conventional microscopy, which have been acquired in the Centriole Lab in University of Geneva (`https://cellbio.unige.ch/research/paul-guichard/`). The usual difficulty for the constitution of a training database is to register perfectly LR and HR image that come from different microscopes with different specifications. To overcome this issue, the intern will follow the approach described in [1] and generate image pairs by simulating the transfer from a real HR modality to a low resolution modality. He /she will have to design several network architectures and modality transfer models and evaluate their performance on our real data.

Working environment

The intern will be a member of the IMAGeS team (`http://images.icube.unistra.fr/`) in the ICube laboratory in Illkirch. Regular meetings will be organized with members of the Centriole Lab in University of Geneva to supervise the biological aspects of the project. The internship will begin between April and June

2020, for a period of 3 to 4 months.
Supervisors: Denis Fortun (CNRS researcher, ICube, `dfortun@unistra.fr`), Paul Guichard (Assistant Professor, University of Geneva, `paul.guichard@unige.ch`) and Virginie Hamel (Senior Scientist, University of Geneva, `virginie.hamel@unige.ch`).

Profile of the candidate

- First year of Master studies in one of the following fields: computer science, applied mathematics, machine learning
- Good programming skills (the coding language will be Python)
- Interest for biomedical applications

Application

Send a CV and a short description of your motivation, as well as the transcript of marks for the past 2 years to Denis Fortun (`dfortun@unistra.fr`).

References

[1] L. Fang, F. Monroe, S. W. Novak, L. Kirk, C. R. Schiavon, B. Y. Seungyoon, T. Zhang, M. Wu, K. Kastner, Y. Kubota, et al. Deep learning-based point-scanning super-resolution imaging. *bioRxiv*, page 740548, 2019.

[2] L. Schermelleh, A. Ferrand, T. Huser, C. Eggeling, M. Sauer, O. Biehlmaier, and G. P. Drummen. Super-resolution microscopy demystified. *Nature cell biology*, 21(1):72–84, 2019.

[3] Z. Wang, J. Chen, and S. C. Hoi. Deep learning for image super-resolution: A survey. *arXiv preprint arXiv:1902.06068*, 2019.

[4] M. Weigert, U. Schmidt, T. Boothe, A. Müller, A. Dibrov, A. Jain, B. Wilhelm, D. Schmidt, C. Broaddus, S. Culley, et al. Content-aware image restoration: pushing the limits of fluorescence microscopy. *Nature methods*, 15(12):1090–1097, 2018.