Super-resolution fluorescent microscopy using GANs

M2 internship proposal for spring 2021 (Duration: 5/6 months)

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Host institution: MORPHEME research group (INRIA, CNRS, I3S, Sophia-Antipolis, France)

Context

Conventional optical microscopy techniques, as confocal microscopes, are widely used in biology for cellular and sub-cellular structures investigation. However, their spatial resolution is limited by the light diffraction phenomena and it is typically around 200nm in the transverse plane and 400nm in the optical axis. Over the recent years, several super-resolution techniques have been developed to overcome this drawback. Popular techniques, such that, for example, SMLM (Single Molecule Localization Microscopy) are based on the use photoactivable molecules, others on structured illumination or on the analysis of the stochastic fluctuation of molecules (such as SOFI) and many more [1]. In the Morpheme group we have developed advanced algorithms for SMLM and for the analysis of SOFI-type images based on sparse optimization reconstruction methods, see, e.g. [2, 3]. The super-resolved image reconstruction is formalized in mathematical terms as an inverse problem which is regularized by introducing a sparsity-promoting penalization. A different and increasingly popular class of methods producing outstanding results in many applied fields is based on the use of modern Deep Learning tools. Among them, Generative Adversarial Networks [4] have attracted the attention of the inverse problem community in recent years [5]. Their use in the field of image microscopy remains limited.

Internship objectives

The purpose of this internship is to develop an inverse super-resolution method based on the use of GANs [4, 5]: the idea is to develop a model capable of finding both the desired image and the parameters of the formation model by minimizing a suitable distance between the distributions of the real images acquired by the microscope and the images synthesized by the model. This approach has already shown promising results in the framework of applied inverse problems, see, e.g., [6]. Its performance will be compared with the methods already developed in the Morpheme research group on synthetic and real data.

Candidate profile

Second year of Master degree in computer science, applied mathematics, data science with background in image processing, imaging inverse problems, deep learning and optimisation. Good coding skills for numerical simulation (Pytorch, Python, MATLAB, ...). A general interest in health and biology is welcome.

Practical information

MORPHEME research team is a joint research group between INRIA Sophia Antipolis Méditerranée., I3S Lab (Université Côte d'Azur and CNRS).

Remuneration: internship gratification (approximately 550 euros/month) and possible discounts for nearby accommodation facilities (CIV).

Application procedure

Please send your CV, motivation letter, marks of the last two years of study and the name and e-mail address of a contact for recommendation to Laure Blanc-Féraud (blancf@i3s.unice.fr), Luca Calatroni (calatroni@i3s.unice.fr).

References

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[6] H. Gupta, M. T. McCann, L. Donati, and M. Unser, "CryoGAN: A New Reconstruction Paradigm for Single-particle Cryo-EM Via Deep Adversarial Learning," *bioRxiv*, 2020.