# Algorithms for curve reconstruction in super-resolution fluorescent microscopy

**3IA Côte d'Azur post-doc proposal (2 years)**

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Hosting lab: Morpheme research team (CNRS, Inria, Sophia-Antipolis, FR).

## Context

Conventional optical microscopy techniques, such as confocal microscopy, are widely used in biology for investigation on cellular and sub-cellular structures. However, their spatial resolution is limited by light diffraction phenomena, which typically prevent structures closer than 200nm to be distinguished in the transverse plane. Among the many existing super-resolution techniques, the exploitation molecule fluctuations attracted the interest of the community due to the fact that it does not need specific fluorophores nor specific illumination or microscope. In this context, the process of reconstructing the super-resolved image is formalized as an inverse problem which is regularized by introducing suitable sparsity constraint. In our team, we have recently proposed both model-based and data-driven approaches for this purpose. The former aim to design discretization-free tailored regularization for the reconstruction of curves [LBFA23], in order to recover filament structures such as fibronectine or microtubules. On the other hand, we have designed physics-inspired data-driven methods aiming at estimating suitable prior regularization models via Plug& Play denoisers [SMCBF23] and/or Wasserstein GANs as suitable data models [CSC+23].

## Objectives

As far as the design of efficient numerical algorithms in an off-the-grid setting is concerned, the problem is challenging, since the optimization is defined in the space of Radon measures which does not possess an Hilbert structure and is not reflexive, which prevents the use of standard proximal algorithms. The post-doc candidate will have to work in this respect on the design and the analysis of iterative schemes encoding, for instance, tailored distances between measures motivated by optimal transport, see, e.g. [SKL20]. Outside the analytical development, one other possibility to go beyond discretization biases is to use of implicit regularization given by neural radiance fields [MST+21] which have been showed to be effective in the continuous representation of scalar fields for several applications in the field of computer vision and inverse problem [SLX+21].

As far as the modeling of data term between distributions is concerned, one idea would be also to follow generative approaches (e.g., GANs and/or diffusion processes) to estimate and sample from the unknown data distribution in combination with a curve-promoting regularization term in the loss function, which is a challenging problem.

## Candidate profile

PhD on optimization and/or image processing. Strong background in applied mathematics, image processing, learning methods and algorithms. Good coding skills (Python, Pytorch, Matlab...). A general interest in health and biology is welcome.

## Practical information

The post-doc will take place within the Inria Morpheme team, a joint research group between Inria centre at Université Côte d'Azur, I3S Lab (Université Côte d'Azur and CNRS) in collaboration with the Machine Learning Genoa Centre (MaLGa) at the University of Genova (Italy). The candidate will be provided with the working material (working station, PC and access to local GPU clusters) as well as with a discounted rate for the close-by Inria canteen, together with a gross salary of 2650 euros/month (including remuneration for teaching hours).

# References


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[MST+21] Ben Mildenhall, Pratul P. Srinivasan, Matthew Tancik, Jonathan T. Barron, Ravi Ramamoorthi, and Ren Ng. Nerf: representing scenes as neural radiance fields for view synthesis. *Commun. ACM*, 65(1):99–106, dec 2021.

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[SLX+21] Yu Sun, Jiaming Liu, Mingyang Xie, Brendt Wohlberg, and Ulugbek S. Kamilov. Coil: Coordinate-based internal learning for tomographic imaging. *IEEE Transactions on Computational Imaging*, 7:1400–1412, 2021.

[SMCBF23] Vasiliki Stergiopoulou, Subhadip Mukherjee, Luca Calatroni, and Laure Blanc-Féraud. Fluctuation-based deconvolution in fluorescence microscopy using plug-and-play denoisers. In *Scale Space and Variational Methods in Computer Vision*, pages 498–510, Cham, 2023. Springer International Publishing.