Pierre Weiss
ANR Micro-Blind

Post-doctoral position

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Dynamic random illumination microscopy & posterior sampling

Scientific goals

The overall goal of the Micro-Blind project is to *design certified inverse problem solvers, with a special interest for Random Illumination Microscopy* (RIM).

Depending on the candidate's interests, we will either consider theoretical aspects of artificial intelligence for inverse problems solving and/or design efficient reconstruction methods for RIM.

On the theoretical side, we would like to better understand the intrinsic limits of unrolled architectures [2] and to accelerate techniques for posterior sampling [1]. Supervised reconstruction methods (such as unrolled neural networks) now provide unprecedented performance for many ill-posed inverse problems. However, the reconstruction are not certified and can lead to beautiful but misleading images. Taking a Bayesian perspective, the ultimate goal of inverse problem solving is rather to infer the posterior probability [1]. However, the current sampling techniques are rather slow, and we want to design more efficient ones.

On the practical side, RIM [5, 4] is a microscopy technique that allows breaking the diffraction limit. It makes it possible to see live biological samples with a near isotropic resolution of about 90nm. The principle is to illuminate the sample with unknown random speckle illuminations. The multiplication pushes high frequency contents within the diffraction band and recover lost frequencies. It is then possible to exploit statistical properties of the speckle to solve the resulting blind inverse problem. Currently, the reconstruction methods are based on the assumption that the sample is fixed in time. The main practical goal of the project will be to derive certified live reconstruction techniques, with an objective to reach a temporal resolution of about 10ms without sacrificing spatial resolution. To this end, we plan to explore the use of both the use of deterministic and artificial intelligence techniques. The problem is relatively well posed in the static context [3]. It is not the case in the dynamic context and we will explore the use of neural network based regularization techniques.

Working conditions

The successful candidate will integrate the newly founded MAMBO team. This team is located at the CBI, a large interdisciplinary research laboratory around fundamental biology. Thus, a lot of data and exchanges with experimental sciences and scientists will be possible. A passionate of optics will be able to change the microscope design together with Thomas Mangeat. A candidate more interested in the more fundamental aspects of mathematics is also more than welcome and will be able to easily exchange with the members of the Toulouse Mathematics Institute.

The post-doctoral position is funded for 48 months. The gross salary is about 3000E/months, with variations depending on the experience.

Deadline & contact

The deadline for application is fixed to the 30 of June 2023. A live or zoom interview will be planned. For any additional information, please contact pierre.weiss@cnrs.fr

Références

[1] H. Chung, J. Kim, M. T. Mccann, M. L. Klasky, and J. C. Ye. Diffusion posterior sampling for general noisy inverse problems. In *The Eleventh International Conference on Learning Representations*, 2023.

[2] A. Gossard and P. Weiss. Training adaptive reconstruction networks for inverse problems. *submitted*, 2023.

[3] S. Labouesse, J. Idier, A. Sentenac, and T. Mangeat. Uniqueness of the random illumination microscopy variance equation. *arXiv preprint arXiv :2103.00493*, 2021.

[4] T. Mangeat, S. Labouesse, M. Allain, A. Negash, E. Martin, A. Guénolé, R. Poincloux, C. Estibal, A. Bouissou, S. Cantaloube, et al. Super-resolved live-cell imaging using random illumination microscopy. *Cell Reports Methods*, 1(1) :100009, 2021.

[5] E. Mudry, K. Belkebir, J. Girard, J. Savatier, E. Le Moal, C. Nicoletti, M. Allain, and A. Sentenac. Structured illumination microscopy using unknown speckle patterns. *Nature Photonics*, 6(5) :312–315, 2012.