Master internship
Fluorescence lensless endoscopy using image-guided wavefront shaping

Non-invasive deep tissue optical imaging is a challenging task in biomedical applications. Light scattering, due to inhomogeneities in the optical refractive index, limits the reach of these techniques to less than a millimeter below tissue surface. Minimally invasive techniques such as endoscopy have been developed to increase the reach of optical imaging while leaving biological tissue as intact as possible. Most of these techniques require nonetheless bulky optical elements at the distal tip of the optical fiber that will be inserted in tissue.
To further reduce this spatial footprint, lensless endoscopy has been developed. Both multimode fibers and multicore fiber bundles (multiple single mode fiber cores inside a common cladding) have been used for this purpose, but the latter exhibits some features that can be beneficial in some practical scenarios, including low coupling between cores and large isoplanetic angular range.
When light propagates through such a waveguide, each core accumulate a given phase delay, which can be pre-compensated by mean of a spatial light modulator. Advanced control on the input wavefront allows then for point scanning or widefield imaging of objects placed in front of the distal tip. These phase delays however need to be measured in a preliminary calibration step, which requires either the presence of a so-called guide-star (i.e. a point-like object lying inside the tissue) or to directly access the distal tip of the fiber in the first place. This calibration is sensitive to the curvature of the fiber, and remains valid only within a given range. Repeated calibration steps are then necessary to compensate for fiber bending, which can be very time consuming in real-life applications.
A new framework has recently been proposed to get rid of this calibration. By shaping the incoherent light that is coming from the object through the multicore fiber bundle, one is able to reconstruct this object through the optimization of an image-based metric. This does not require any access to the distal side of the fiber, nor the presence of guide stars inside tissue. During this internship, the student will build on this framework and adapt it to perform for the first time calibration-free widefield linear fluorescence imaging through a multicore fiber bundle. It will involve experimental optics as well as computational image reconstruction.

Requirements

Candidates with a strong background in physics, optics, electrical engineering, or any related field are encouraged to apply. Programming skills would be beneficial (Matlab or Python), as well as a certain taste for tinkering. As they will be evolving in an international environment, the candidates must be fluent in English, and exhibit excellent communications capabilities (written and spoken).

Host lab

The project will be carried out at the Fresnel Institute in Marseille, within the MOSAIC group. Gathering more than 40 people from around the world, this interdisciplinary group is working at the crossroad of physics and biology.

Application procedure

Please send a detailed CV, a cover letter, as well as names, affiliations, and email addresses of two references to thomas.chaigne@fresnel.fr. Make sure to mention “[Application]” in the email object.