INTERNSHIP PROPOSAL

(One page maximum)

Laboratory name: Wavefront Engineering Microscopy team, Photonics Dpt. Vision Institute
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Thesis possibility after internship: YES

Fast light shaping for imaging of neuronal activity

A non-invasive approach to visualize neuronal activity with single cell resolution is critical to understand how the brain works, how it computes information and controls behavior.
In recent years, the introduction of genetically expressed indicators of neuronal activity, **opened the way to optically detect neuronal activation via fluorescent optical imaging**. The development of dedicated imaging approaches is critical to fully exploit this capability. In particular, efforts are dedicated to image large field-of-views, with high acquisition speed and in deep region inside scattering tissue[1].

The wavefront engineering microscopy group, at the Vision Institute, is pioneer in the development of advanced optical techniques applied to Neuroscience. In particular, it focuses on **approaches based on wavefront shaping and phase modulation of laser beams**, using Spatial Light Modulators (SLM), to generate arbitrary illumination patterns deep in living tissue[2].

In this project, we propose to apply a recent technique for generation of 3D multispot holographic illumination[3], combined with a camera or single-pixel detector and signal reconstruction algorithms in order **to develop a novel approach for fast volumetric imaging of neuronal activity**.

More precisely, a recent optical configuration, named FLiT [4], will allow the generation of fast sequences of illumination pattern, capable of targeting selectively subgroups of neurons, resulting in complex integrated fluorescence signals varying over time. By leveraging this capability and the use compressive sensing based reconstruction algorithm[5], we will aim to reconstruct the activity of each cell at high acquisition rate.
During the internship, the student will work on the implementation and validation of the approach and, according to his/her interest, will focus either on the **data processing and signal reconstruction** part or on the experimental **implementation of the optical setup and the recording** on simple biological preparations such as organotypic brain slices and zebrafish.

References:

[1] Ji, N., et al. Technologies for imaging neural activity in large volumes. *Nat. Neurosci*. 19, 1154–64 (2016).
[2] Ronzitti, E. et al. Recent advances in patterned photostimulation for optogenetics. *J. Opt*. 19, (2017).
[3] Accanto, N. et al. Multiplexed temporally focused light shaping for high-resolution multi-cell targeting. *Optica* 5, 1478 (2018).
[4] Faini, G, Tanese D. et al. Ultrafast light targeting for high-throughput precise control of neuronal networks, *Nature Comm.*, 14,1888 (2023).
[5] Gibson, M et al. Single-pixel imaging 12 years on: a review, *Optics Express*, 28, 19 (2020).

Please, indicate which speciality(ies) seem(s) to be more adapted to the subject:

Condensed Matter Physics: YES Soft Matter and Biological Physics: YES
Quantum Physics: YES Theoretical Physics: NO