Internship : M2 Neuroscience
Institut de Neurosciences de la Timone
-
In search for local connectivity hubs in the superficial white matter
Exploring pyramidal shape crossings with ultra-high resolution MR data

Context

Magnetic Resonance (MR) imaging has been a critical advance to explore brain anatomy and function. In particular diffusion MR imaging has opened the possibility to explore white matter architecture and track fiber bundles (tractography techniques). Still, superficial white matter and its short-range fibers are still very much unknown since tractography does not perform very well in superficial white matter. This is due to a higher level of partial volume (proximity to the cortex), a more complex geometries of these specific fibers that requires a high spatial resolution, and a probable higher inter-subject variability compared to long-range fibers.

Nevertheless, recent post-mortem dissection work [1] showed the presence of specific cortical features, *pyramid shape crossings*, that are the convergence of short-range fibers and hypothesized to be hubs of superficial short-range fibers connectivity (Fig. 1). The goal of this internship is to investigate the presence of such hubs and associated connectivity using ultra high-resolution diffusion data acquired on single subject [2].

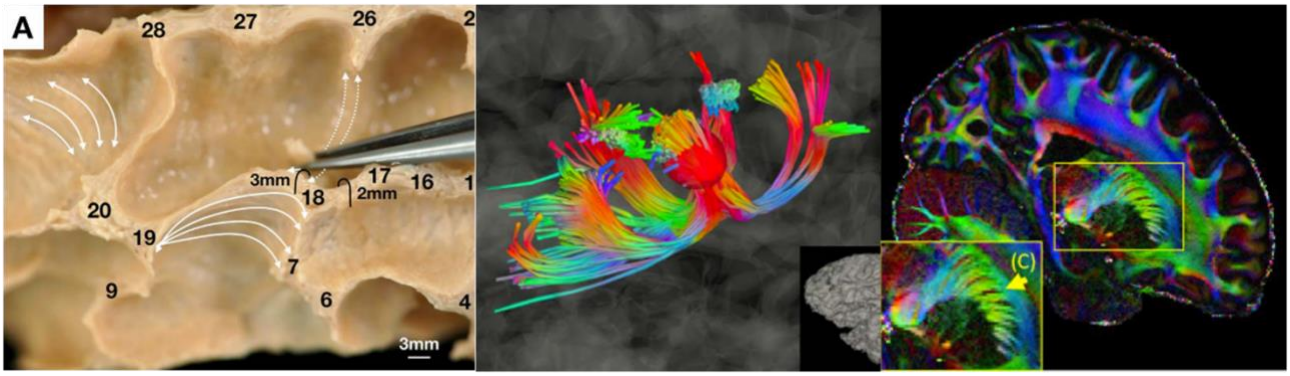

Fig. 1: local superficial WM dissection (left) and tentative tractography of a 3-way junction (middle) from [1], and ultra high-resolution diffusion MRI from [2]

Objectives

The candidate will study pyramid shape crossings using a state-of-the-art software (MRTrix3, https://www.mrtrix.org/) with which specific methods have been developed to extract short range superficial connectivity [4,5]. He/She will use the MGH Single Subject [2], a publicly available in vivo dataset (acquired from on a single healthy subject), containing a set of 18 diffusion MRI volumes at 760 µm isotropic resolution (Fig.1, right), and the corresponding high-resolution structural average images (T1-weighted or T2-weighted volumes) at 700 µm isotropic resolution, from 9 two-hour sessions [3]. With supervision, the candidate will learn how to locate pyramid-shape crossings on the cortical surface of the subject and to perform the appropriate tractography technique from these, in order to find short fiber junction (SFJ) areas.

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In a second phase, the candidate will characterize the SFJ patterns by studying their topology (simple u-fibers, 2-way or n-way fibers) and estimating quantitative derived SFJ maps (for example densities, lengths or angles of tracts). Depending on the advancement of the project, the last step would be to attempt to infer superficial short fiber networks around specific cortical sulci.

Required Skills

We are looking for a neuroscience M2 student, motivated by macroscopic neuroanatomy, and computational neuroscience, with at least basic knowledge of MRI data.

Work Environment

The internship is at the Institut de Neurosciences de la Timone (INT), in Marseille, France, a large neuroscience institute that performs fundamental, translational, and clinical research at all scales, and on various cognitive functions. The intern will integrate the MeCA research team of the Institut des Neurosciences de la Timone, in Marseille, France. Meca has a long-lasting expertise in computational neuroanatomy and processing of MR data. Tools and data required for the internship will be provided by the team.

How to apply

Send your CV + motivation letter to olivier.coulon@univ-amu.fr and arnaud.le-troter@univ-amu.fr

References

[1] Shinohara, H. et al. (2020). Pyramid-shape crossings and intercrossing fibers are key elements for construction of the neural network in the superficial white matter of the human cerebrum. *Cerebral Cortex*, *30*(10), 5218–5228. https://doi.org/10.1093/cercor/bhaa080

[2] Wang, F. et al (2021). In vivo human whole-brain Connectom diffusion MRI dataset at 760 µm isotropic resolution. *Scientific Data*, *8*(1), 1–12. https://doi.org/10.1038/s41597-021-00904-z

[3] Wang, F. et al. (2021). Data from: In vivo human whole-brain Connectom diffusion MRI dataset at 760 µm isotropic resolution (PART II).
Dryad https://doi.org/10.5061/dryad.rjdfn2z8g

[4] Gahm, JK., et al. (2019) Surface-based Tracking of U-fibers in the Superficial White Matter. Med Image Comput Comput Assist Interv. 2019;11766:538-546. Epub 2019 Oct 10. PMID: 33860288; PMCID: PMC8046261.

[5] Shastin, D., Tax, M. W., Genc, S., Parker, G. D., Koller, K., Gray, W. P., & Derek, K. (2021). Surface-based tracking for short association fibre tractography Keywords : *NeuroImage*, *260*(June), 119423. https://doi.org/10.1016/j.neuroimage.2022.119423

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