Tractography modelling of Deep Brain stimulation for Parkinson's disease

Background Deep Brain Stimulation (DBS) is an effective treatment in advanced Parkinson's disease patients to control motor symptoms such as bradykinesia, rigidity, or tremor. DBS leads are implanted in the basal ganglia, which is connected to the cortex through, e.g., the direct, indirect and hyperdirect pathways. Recent studies suggest that DBS stimulation of the hyperdirect pathway plays an important role in the effects of the treatment[1,2]. Tractography can be used to identify these pathways and help understand the effects of DBS.

DBS patients are clinically assessed about four to six months after the surgery to evaluate the effect and side effect thresholds of DBS. This assessment results in stimulation parameters and a clinical outcome, that can be used to obtain the activation of these pathways. Then, the activation of the pathways can be associated with the clinical outcome.

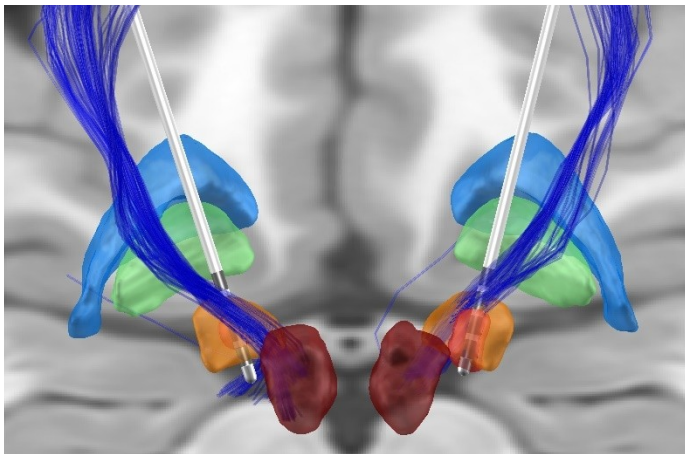

Figure 1. 3D illustration of DBS leads and subcortical structures. Subthalamic nucleus in orange, volume of tissue activated in red and streamlines in dark blue.

Aim The student will perform the reconstruction of the pathways of interest on a *newly implemented diffusion MRI* sequence using tractography. Then, the student will reconstruct the electrode locations of the patients implanted at Inselspital Bern, and generate the volumes of tissue activated by each of the electrode contacts using clinical stimulation settings recorded during the post-operative clinical assessment of DBS. The student will generate an activation model of the pathways and relate it to the clinical outcome. Finally, the student will compare the obtained activation thresholds to previous activation models and evaluate the usability of the new diffusion MRI sequence.

Materials and Methods The student will use MRtrix3 (https://www.mrtrix.org/) for the tractography analysis and the Matlab toolbox Lead-DBS (https://www.lead-dbs.org/) for the leads' reconstruction and generation of VTAs.

Nature of the Thesis Literature review: 20% | Data analysis and programming: 60% | Writing: 20%

Requirements Interest in brain connectivity and image analysis. Programming knowledge in Matlab and/ or Python.

Supervisors Alba Segura Amil, Dr. T. A. Khoa Nguyen (Department of Neurosurgery, Inselspital Bern; ARTORG Center for Biomedical Engineering)

Prof. Claudio Pollo (Department of Neurosurgery, Inselspital Bern)

Contact Alba Segura Amil, alba.seguraamil@insel.ch, Murtenstrasse 50, CH-3010 Bern, Tel. 031 632 32 18

References

1. Oswal, A. *et al.* Neural signatures of hyperdirect pathway activity in Parkinson's disease. *Nat. Commun.* **12**, 1–14 (2021).

2. Gunalan, K. *et al.* Creating and parameterizing patient-specific deep brain stimulation pathway-activation models using the hyperdirect pathway as an example. *PLoS One* **12**, 1–19 (2017).