# Probabilistic Stimulation Maps for Deep Brain Stimulation

**Background** Deep Brain Stimulation (DBS) is an established therapy for movement disorders such as Parkinson's disease. Stimulation leads are typically implanted in the subthalamic nucleus. Electrical stimulation is then applied to treat the symptoms of the disease. The exact mechanisms are still unknown, but it is widely accepted that the 'motor part' of the subthalamic nucleus should be targeted for beneficial outcome. But this serves as a mere signpost and leaves the clinician with the arduous work of finding adequate stimulation parameters for the patient. Finally, this manual programming is time-consuming and may result in sub-optimal stimulation settings for the patient.

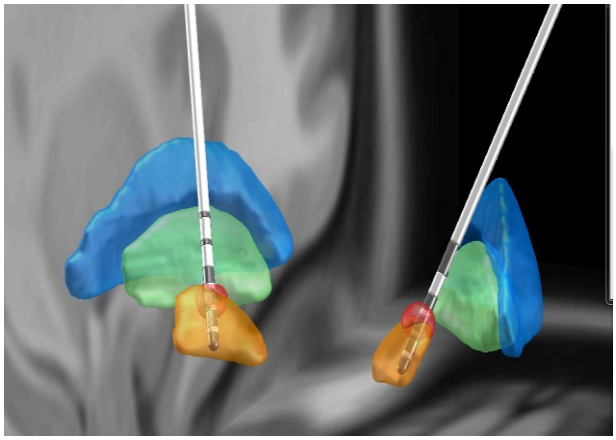

*Illustration of stimulation leads and subcortical structures. Subthalamic nucleus in orange and volume of tissue activated in red. These volumes activate the 'motor part' of the nucleus.*

To facilitate programming, *probabilistic stimulation maps* (PSM) identify sweet spots of stimulation, i.e., regions that, when activated, are likely to result in beneficial outcome. These maps are built from patient data: the position of DBS leads, stimulation volumes and the corresponding clinical outcomes. This data is then combined with voxel-based statistical learning to determine sweet spots. In future, computer-assisted programming may scan these maps and readily suggest stimulation parameters for beneficial outcome, thus saving the clinician and patient valuable time.

Last year, we published a PSM for the subthalamic nucleus for Parkinson's disease [1] and drew inspiration from previous publications [2,3]. In the process, we realized that many ways exist to generate these maps. It is unclear at the moment whether an optimal method exists and how it should be designed.

**Aim** The student will first compare different methods for generating PSMs from the literature. Following this review, the student will then implement a selected number of these methods. The student is also encouraged to implement new ideas for PSM generation, for instance, using federate learning [4]. The resulting PSMs will be trained and tested with retrospective data from Inselspital patients.

**Materials and Methods** The student will implement the models in Matlab with the open-source toolbox Lead-DBS.

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

**Requirements:**
Interest in machine/ statistical learning
Programming knowledge in Matlab

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**References:**

[1] Nguyen TAK, Nowacki A, Debove I, Petermann K, Tinkhauser G, Wiest R, et al. Directional stimulation of subthalamic nucleus sweet spot predicts clinical efficacy: Proof of concept. Brain Stimul. Elsevier Ltd; 2019;12: 1127–1134. doi:10.1016/j.brs.2019.05.001
[2] Eisenstein SA, Koller JM, Black KD, Campbell MC, Lugar HM, Ushe M, et al. Functional anatomy of subthalamic nucleus stimulation in Parkinson disease. Ann Neurol. 2014;76: 279–295. doi:10.1002/ana.24204
[3] Dembek TA, Barbe MT, Åström M, Hoevels M, Visser-Vandewalle V, Fink GR, et al. Probabilistic mapping of deep brain stimulation effects in essential tremor. NeuroImage Clin. The Authors; 2017;13: 164–173. doi:10.1016/j.nicl.2016.11.019
[4] https://ai.googleblog.com/2017/04/federated-learning-collaborative.html , last retrieved August 29, 2019.