# Developing Optimization Algorithms for Computer-Assisted Programming

**Background** Deep Brain Stimulation (DBS) is an established treatment for movement disorders such as Parkinson's disease. Stimulation leads are typically implanted in the subthalamic nucleus to apply electrical stimulation. This ameliorates the symptoms of the disease but requires extensive manual stimulation programming that can take several hours. This is laborious for the clinician, uncomfortable for the patient and inefficient.

*On the right: 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.*

The objective of computer-assisted programming is to suggest stimulation settings. We have analyzed retrospectively patient data to calculate stimulation maps, e.g., [1]. These maps highlight the stimulation 'destination'. However, we lack navigation or optimization algorithms that guide the stimulation to the destination. Thus far, we have used brute force or have made simplifying assumptions [2]. Another group suggested unconstrained optimization but with a different stimulation map [3].

**Plan** First, the student will review the literature on computer-assisted programming. Second, she/he will pilot optimization algorithms for monopolar, and later, multipolar stimulation. Third, she/he will perform extensive evaluation against clinical data. What is the error between the computed suggestions and the clinical settings?

**Materials and Methods** The student will receive stimulation models and stimulation maps as Nifti files. The stimulation maps are specifically for Parkinson's disease and essential tremor. There are different types of stimulation maps, i) with volumetric sweet spot, ii) regression coefficients for each voxel, iii) a neural network (in progress). Together can be used in Matlab or Python to develop optimization algorithms (e.g., fminunc in Matlab or scipy.optimize in Python).

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

**Requirements:**
Programming knowledge (e.g., Matlab, Python)

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**References:**
[1] Nguyen, T A Khoa, et al. "Directional stimulation of subthalamic nucleus sweet spot predicts clinical efficacy: Proof of concept." Brain stimulation 12.5 (2019): 1127-1134.
[2] Nordenstrom, Simon, et al. "Programming of Subthalamic Nucleus Deep Brain Stimulation for Parkinson's Disease with Sweet Spot-Guided Parameter Suggestions", Frontiers in Human Neuroscience, under review.
[3] Roediger, Jan, et al. "StimFit—A Data-Driven Algorithm for Automated Deep Brain Stimulation Programming." Movement Disorders 37.3 (2022): 574-584.