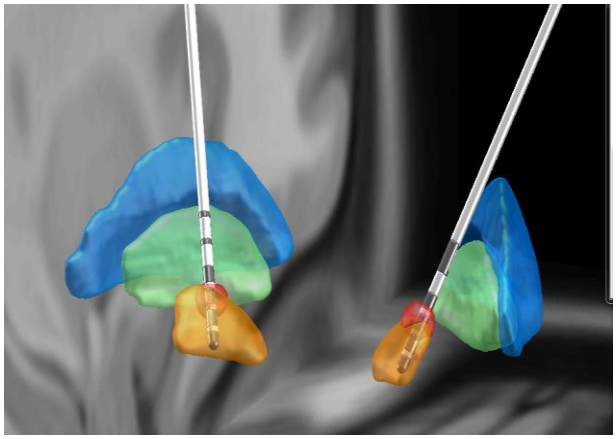
Evaluating Different Stimulation Models for Deep Brain Stimulation



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 the exact mechanisms remain debated.

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.

To better understand the mechanisms and to optimize the treatment, various computational models have been proposed to compute the **volume of tissue activated**, i.e., the brain area activated by the stimulation. The original work dates from the early 2000s and was computationally complex and expensive [1]. Other approaches make simplifying assumptions to accelerate the computation, e.g., [2]. We have also developed a model to account for anisotropic brain tissue [3]. However, a comprehensive evaluation of the various models, their strengths and weaknesses is missing.

Aim First, the student will review the literature on stimulation models. Second, she/he will setup the different models inside Matlab and Lead-DBS (maximum five models). Third, the models will be used to calculate stimulation maps for two indications, Parkinson's disease and essential tremor. Fourth, the stimulation maps will be evaluated against clinical data to compare the performance of the models.

Materials and Methods The student will estimate the stimulation volumes in Matlab with the open-source toolbox Lead-DBS. Lead-DBS includes various stimulation models, notably, FastField, SimBio/Fieldtrip, OSS. In addition, our previous work adds a patient-specific anisotropic stimulation model [3].

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

Requirements:
Interest in machine learning
Programming knowledge (e.g., Matlab)

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References:

[1] McIntyre, Cameron C., et al. "Electric field and stimulating influence generated by deep brain stimulation of the subthalamic nucleus." Clinical neurophysiology 115.3 (2004): 589-595.
[2] Åström, Mattias, et al. "Relationship between neural activation and electric field distribution during deep brain stimulation." IEEE Transactions on Biomedical Engineering 62.2 (2014): 664-672.
[3] Garza, Roberto, et al. "Patient-Specific Anisotropic Volume of Tissue Activated with the Lead-DBS Toolbox." 2021 43rd Annual International Conference of the IEEE Engineering in Medicine & Biology Society (EMBC). IEEE, 2021.