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Learning from the Past: Probabilistic Deep Brain Stimulation Atlas Based on Intra-Operative Data.

Dorian Vogel¹, Karin Wårdell², Jérôme Coste^{3,4}, Jean-Jacques Lemaire^{3,4} and Simone Hemm^{1,2}

1. Institute for Medical Engineering and Medical Informatics, School of Life Sciences, University of Applied Sciences and Arts Northwestern Switzerland, Muttenz, Switzerland
2. Department of Biomedical Engineering, Linköping University, Linköping, Sweden
3. Pascal Institute, Clermont-Auvergne University, Clermont-Ferrand, France
4. Department of Neurosurgery, Clermont-Ferrand University Hospital, Clermont-Ferrand, France

Background

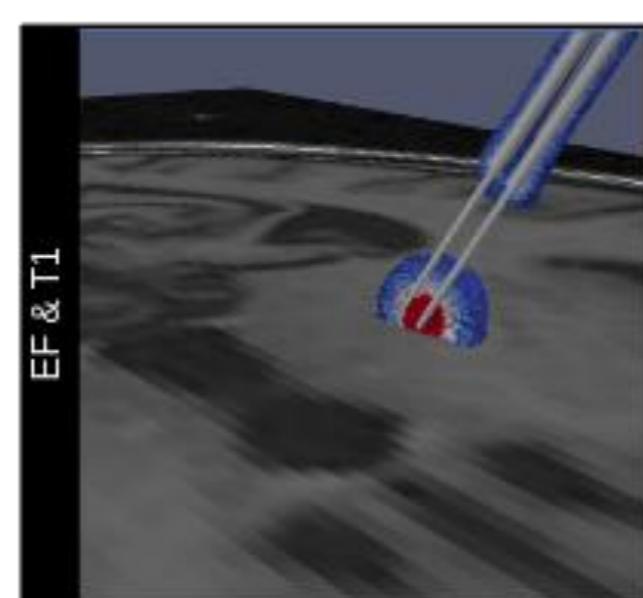
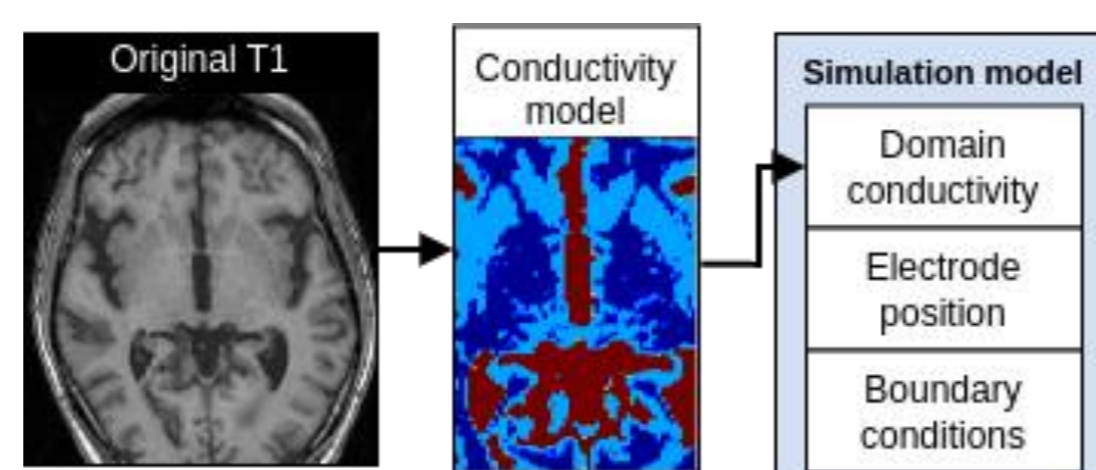
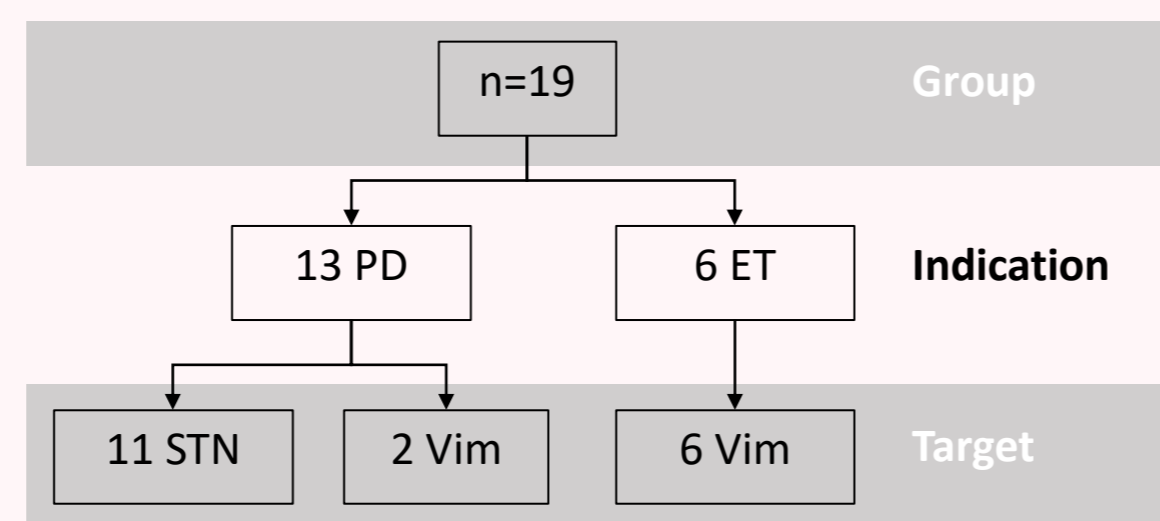
- The placement of the Deep Brain Stimulation (DBS) electrode at the most effective location in the brain for the control of symptoms of movements disorders is challenging.
- The use of intra-operative tests stimulation has been the standard and stays very common despite the strong trend towards implantation under general anesthesia.
- To better understand the mechanisms behind DBS, normative analysis has a great potential. These allow analyzing the stimulation-effect relationship at a group level resulting in probabilistic stimulation maps (PSMs).

Aim: Develop and Setup a pipeline for group-analysis to evaluate the potential of intra-operative test data for the generation of PSMs.

Method

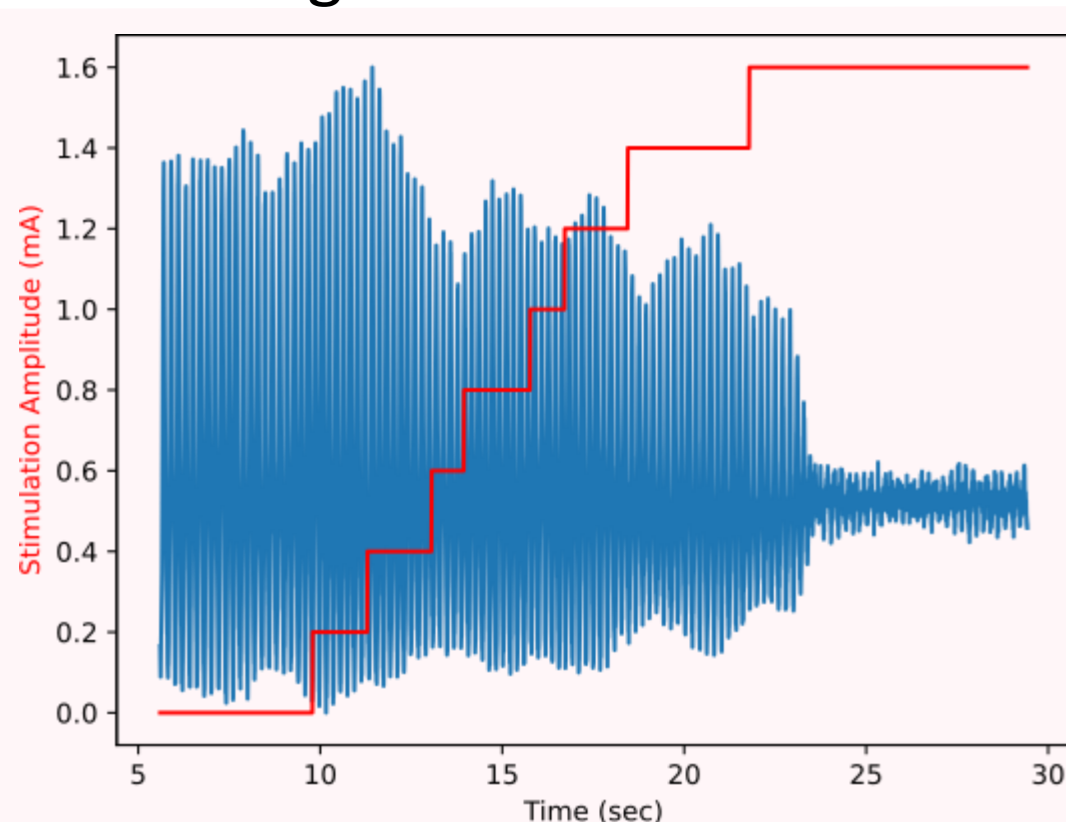
Clinical Data:

- 19 patients implanted under local anesthesia with MER and test stimulation (2 parallel electrodes)
- Imaging: preoperative stereotactic T1 and WAIR (white matter attenuated inverse recovery).



Volume of tissue activated:

- Patient-specific isotropic conductivity model based on T1 contrast.
- Electrode placed based on intraoperative Leksell Frame settings.



Symptoms scores:

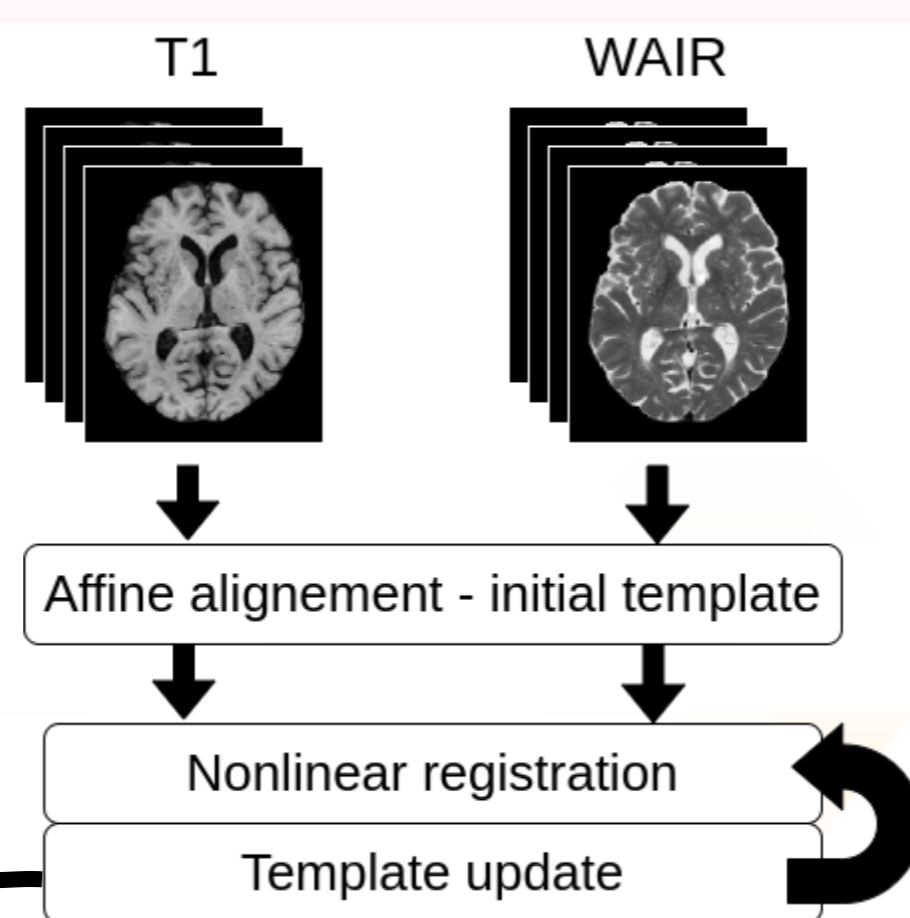
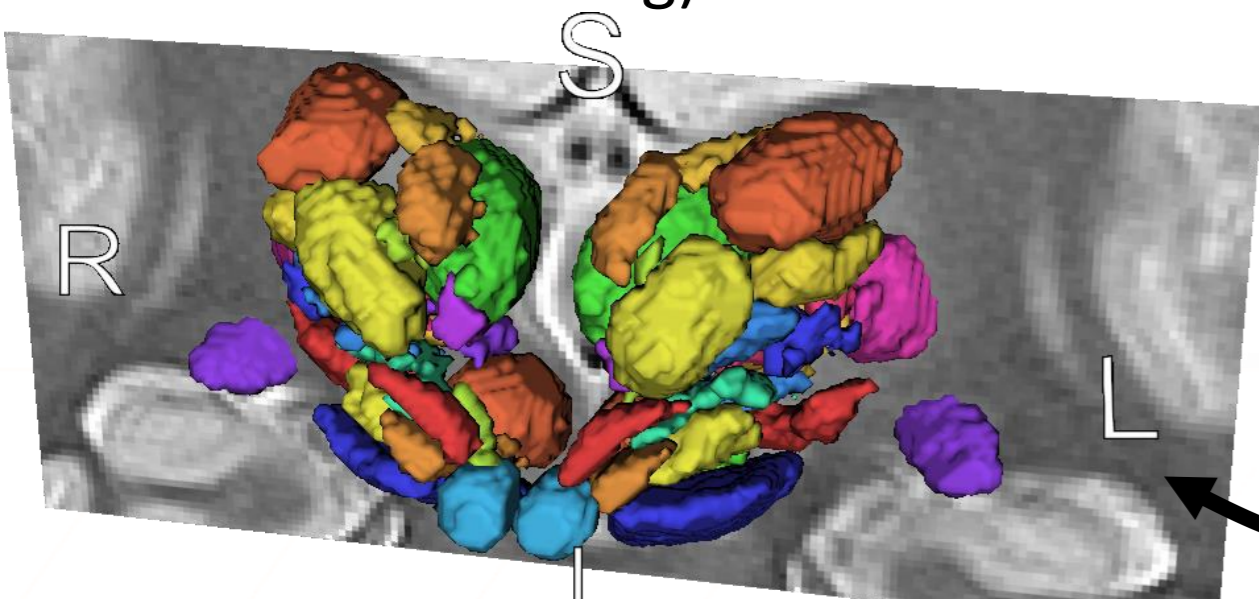
Quantitative tremor scoring based on wrist-worn 3D acceleration sensor (400Hz). Synced with stimulation amplitude changes.

Metrics: standard deviation of magnitude, amplitude at peak frequency, signal energy.

Anatomical Normalization:

Group-specific template

- Iterative mixed-modality pipeline
- 37 deep brain structures defined (based on patient-specific, single-expert manual labeling).



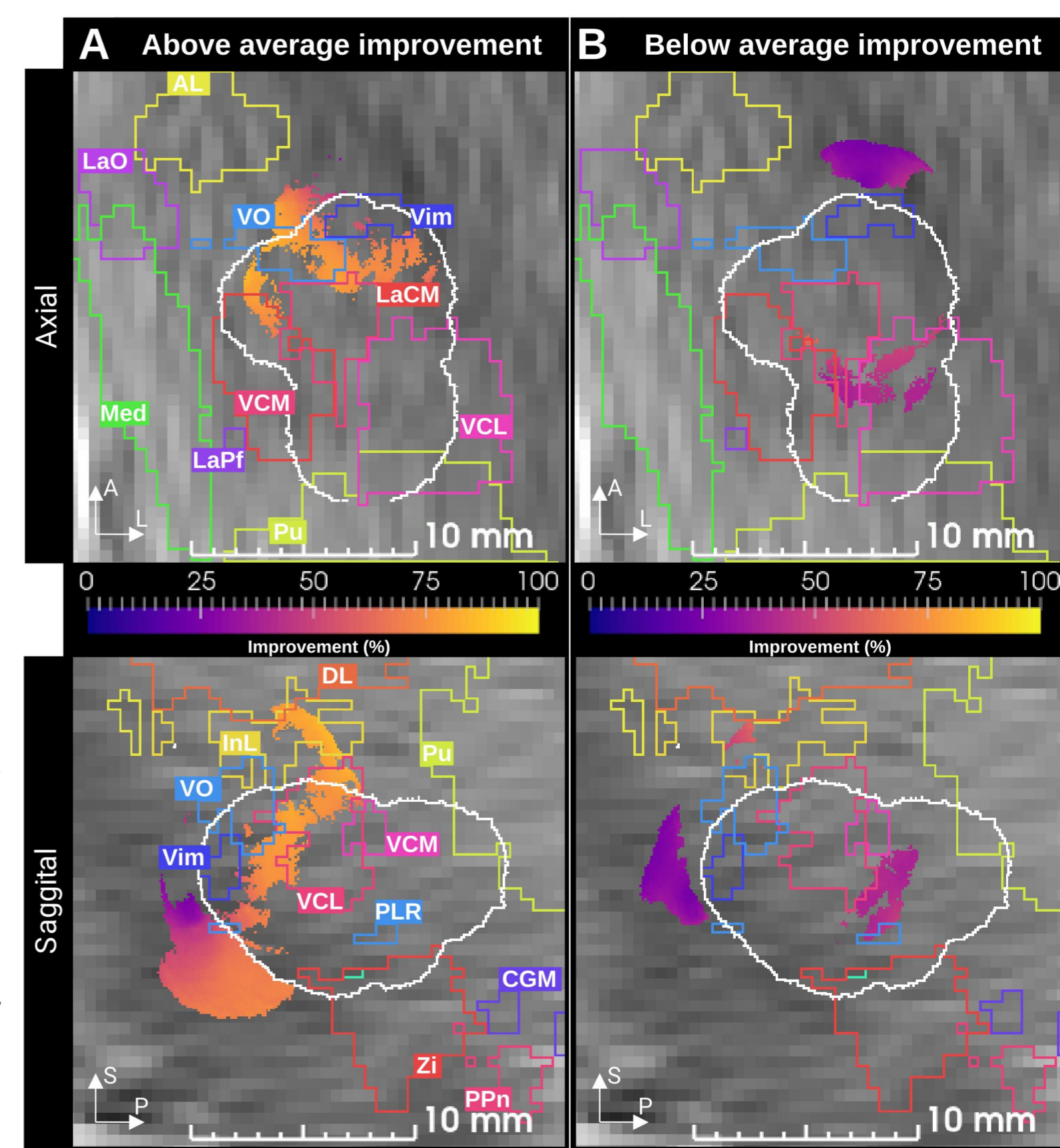
Probabilistic Stimulation maps

Resolution of overlap between VTAs associated with different tremor scores after transformation in template space. Analysis for the 6 Essential tremor patients only.

- Number of stimulations for each voxel: nMap
- Best overall outcome for each voxel: maxMap
- Voxels significant for greater tremor reduction: weighted mean map + signed t-test (against average improvement) per patient & majority voting.

All maps visualized in atlas space, with anatomical labels from the group.

Results



Weighted mean Map masked with the result of the significance test result (t-test). A: significant for tremor reduction above average; B: significant for tremor reduction below average.

- 1708 stimulation tests in 6 patients simulated, normalized and analyzed.
- Regions with above average improvements located posterior to Vim-Vo and anterior to VCL-VCM, extending down in the Posterior subthalamic Area (Zona incerta).
- Regions associated with worst improvement at the anterior and posterior limits of the ROI.
- Automatic and reproducible pipeline

Conclusion

- Design and implementation of reproducible, automatic group-specific analysis pipeline for analyzing outcomes during intraoperative DBS tests.
- Promising results obtained despite the small number of patients.
- Outlook:
 - better statistics methods in the weighted mean map.
 - more patients (acquisition in progress).

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