Group-wise Deep Brain Normalization Pipeline Optimization for Speed and Quality

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Introduction

Anatomical population templates enable population-wide studies, by providing a common reference ground for normalizing patient-specific observations and enabling statistical analysis. This approach is used for the analysis of clinical data from patients implanted with Deep Brain Stimulation (DBS) systems with the goal to further explore and refine the mechanisms of action of stimulation depending on the disease.

Methods

Preoperative MRI imaging data from 67 patients implanted with DBS systems at the university hospital Clermont-Ferrand (France) for Parkinson's disease and essential tremor were used in this study. For each patient two sequences were acquired, and deep brain structures were segmented during the planning of the surgery as part of the clinical protocol.
The anatomy of all patients was normalized using an iterative non-biased template generation pipeline using successive non-linear registrations of the patient images to update the group reference. Image registrations were run with ANTS, the normalization was repeated with increasing number of patients. Runtime and quality were optimized by using full-brain and deep-brain masks for registration and progressive partial sampling. In the process, structure segmentations for all patients were transformed in template space and used to benchmark the registration pipeline by measuring the dice overlap between the definition of the different structures between patients. Turkey HSD test was used to access the significance of differences between template generation runs.

Results

The overlap score results highlight the importance of the switch from full-brain-focused to deep-brain-focused registration and suggest that 44 patients as the optimal number of patients.

Conclusion

By using partial sampling and registration masks, the quality of the results produced by the deep-brain focused group-specific normalization pipeline was increased and computing time reduced. This lays the foundation for more precise probabilistic effect analysis studies and better understanding of the mechanisms of effect of DBS.

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