Supporting Deep Brain Stimulation Interventions by Fusing Microelectrode Recordings with Imaging Data

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What is Deep Brain Stimulation?
Deep Brain Stimulation (DBS) is a neurological procedure to reduce tremor and other motor disfunctions arising from diseases like Parkinson’s Disease.

Acquisition of Pre-Operative Imaging Data
T1-weighted MRI  T2-weighted MRI  CT  X-Ray

Problem: The target region is not visible in any modality and its position can therefore only be estimated heuristically.

Patient Checks
After placing and activating the stimulating electrode, patient checks are performed to verify the electrode’s position. The surrounding regions react differently to stimulation and these reactions, e.g., temporary memory loss, increased tremor, can be tested. All data points from the patient checks lie on the access path, which spans from the burr hole in the head to the target region, and have an uncertainty with them.

Problem: The surgeon needs to keep track of the information from different checks in his head and relate them to other information sources.

Micro Electrode Recording
An MER is obtained by advancing a small electrode towards the intended target region while recording the brain’s electric field. The discharge pattern of neurons is distinct for each functional region and can thereby be used to distinguish functional areas.

Recording Phase
In the recording phase, the MER signals are analyzed and the respective regions are represented by colored beads trailing the electrode (upper part). The lower part allows for direct access to the raw data and, hence, more detailed inspection.

3D Spatiotemporal Audio Visualization
By combining knowledge about the electrodes’ location and orientation with the detected signal, we relieve the surgeon of the burden of having to fuse these information in his head.

In the placement phase, the stimulating electrode is advanced and the patient checks are performed. All previously recorded data is still available for inspection to find the optimal placement position. The lowest image shows the combined information from the MER scans (red/green color-mapping), the electrode, and the results from the patient checks (ellipses with transparent outer shells showing the uncertainty.

Problem: The surgeon needs to maintain a mental registration between the oscillogram and the spatial position of the electrodes which requires concentration and is error-prone.

Results
We combine all data into two major views, one for the MER recording phase (left figure), the other for the electrode placement phase (right figure). Each of the views reuses components to create a mental registration between them. This frees some of the surgeon’s mental capacity to perform a better operation.