« Preoperative SEEG electrode placement planning using deep learning based on clinical hypotheses»

Location: ICUBE Institute, IMAGeS group, University of Strasbourg (https://icube.unistra.fr)
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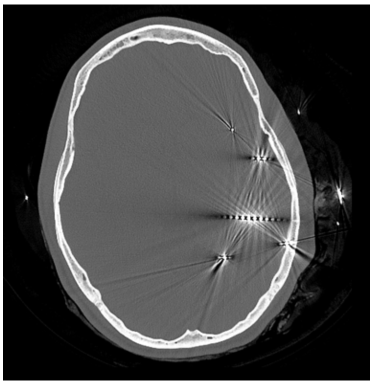
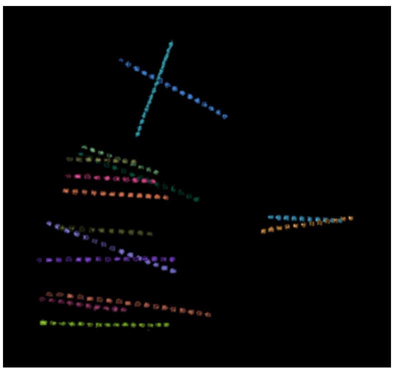
Start: Sept 1st, 2023
Duration: 3 years
Application deadline: **May 20th, 2023**
Funding: 24.000 € annual salary (~19.000 € net annually, health insurance included)
Possibility to get teaching assistantship (~ 400 €/month)

Context:
Epilepsy is a chronic neurological disease that affects approximately 50 million people worldwide. More than 30% of patients are resistant to current antiepileptic drugs. For patients with drug-resistant focal epilepsy of structural etiology [1], surgical removal of the epileptogenic zone may be an appropriate therapeutic option.



This topic is placed in the context of the preparation of epilepsy neurosurgical procedures. In this study, we wish to go beyond planning electrode trajectories based on geometry, anatomy, and the neurologist's placement instructions. The objective here is to start from clinical hypotheses and hundreds of retrospective cases, and to use the power of deep learning to propose relevant placement scenarios for optimal exploration of epileptogenic areas.

In surgery, planning the procedure is a decisive step. The chances of success of a surgical operation depend strongly on a good preparation and the choice of the most appropriate strategy [2]. Nowadays, the practitioner relies mainly on images to establish this strategy. A few days before surgery, CT or MRI images of the patient are acquired, and the practitioner develops his or her surgical plan from these sets of preoperative 2D slices. In the case of epilepsy neurosurgery, this is a difficult task because the practitioner will not have a direct view of the targeted areas. He must mentally picture a 3D model of the patient's anatomy and the position of these areas, and evaluate a three-dimensional trajectory that is both safe and will maximize efficiency. When required to plan trajectories for many electrodes at once, the task becomes even more complicated due to placement interactions or constraints between the tools. Previous studies conducted within the IMAGeS team have developed a first approach to automated electrode position planning to target selected anatomical areas for exploration [3][4].



But such a purely geometrical calculation is not enough. In epilepsy neurosurgery, an additional difficulty lies in the optimal choice of the areas to be explored. The initial aim of this surgery is to find the epileptogenic zone, i.e. the source of the epileptic seizures, in order to be able to neutralize it surgically. The implantation of 10 to 18 electrodes to record neuronal activity allows us to verify if the areas where they have been placed are epileptogenic. However, for the detection to be done correctly, it is necessary that at least one electrode is placed there, whereas it is an unknown. Currently, neurologists and neurosurgeons choose the areas to be explored empirically, based on multiple and varied hypotheses, related among others to symptoms, clinical scores, or external EEG prerecordings.

Mission:

In this thesis, we will propose not only geometrically optimal but also clinically relevant electrode placement, basing the choice of targeted areas on multiple and heterogeneous data types. Deep learning techniques based on numerous retrospective cases will be implemented and compared to usual numerical optimization techniques used as reference. A challenge will be to use these methods not to classify a potential solution as valid or not, but prospectively to propose placement combinations as solutions. Methods based on reinforcement learning will be considered. Data collection in several centers, involving an ontological component, as well as work on consistent annotation, will be important steps in this topic.

The thesis work will build on previous results of the IMAGeS team of ICUBE, in which methods for the optimization of surgical trajectories have been developed for several years. It will be done in collaboration with several academic and hospital partners, and in particular the University Hospital of Strasbourg.

Bibliography

[1] Scheffer IE, Berkovic S, Capovilla G, et al. *ILAE classification of the epilepsies: position paper of the ILAE commission for classification and terminology*. vol. 58. Wiley online library. p.512–521, 2017

[2] Talairach J, Bancaud J. *Lesion, "irritative" zone and epileptogenic focus*. vol. 27. Karger Publishers. p. 91–94, 1966

[3] Pantovic A, Ollivier I, Essert C. *2D and 3D-UNet for segmentation of SEEG electrode contacts on post-operative CT scans*. In: SPIE Medical imaging 2022: image-guided procedures, robotic interventions, and modeling; vol. 12034, 2022

[4] Pantovic A, Ollivier I, Essert C. *Hybrid UNet for segmentation of SEEG electrodes on post-operative CT scans*, Computer Methods in Biomechanics and Biomedical Engineering: Imaging & Visualization, Taylor & Francis, 2022

Qualifications: Master's degree in computer science or a related field. A very good level of programming in C++ or Python is required. Good communication skills and a good level of English are desired. Expertise in deep learning methods is expected. Knowledge in computer graphics and numerical methods would be a plus.

To apply: Send a CV, cover letter, master internship report, master transcripts with ranking, and the names and contact information of at least 2 people who can recommend you to Caroline ESSERT: essert@unistra.fr

NB: Incomplete applications without information about the student's ranking in his/her master's program will not be considered.