Experimental Audiology Lab
Klinikum rechts der Isar
Technical University of Munich

Master’s thesis: Multi-modal AI Models for Cochlear Implant Insertion Depth Estimation

Background

Cochlear implants (CIs) are highly effective neuroprosthetic devices for individuals with hearing loss. Accurate knowledge of CI electrode positioning can enhance patient outcomes. While postoperative imaging techniques like computed tomography (CT) provide precise electrode localization, they are expensive and expose patients to radiation. Therefore, a non-radiative alternative is advisable for routine clinical use.

CIs feature impedance telemetry, which provides data about the electrical characteristics of electrode contacts and offers insights into intracochlear positioning. Preliminary work with multi-modal deep neural networks for linear insertion depth regression have shown promise and improved in precision over benchmark models. However, existing multi-modal models used for the estimation do not fully capture the complex relationship between impedance measurements and CT images. Further research is needed to develop advanced multi-modal architectures capable of fully leveraging the information contained in CT images.

Aim

In this project, you will implement and test advanced multi-modal deep learning models in an existing dataset to estimate cochlear implant electrode insertion depths based on CT scans and impedance recordings from the cochlear implant.

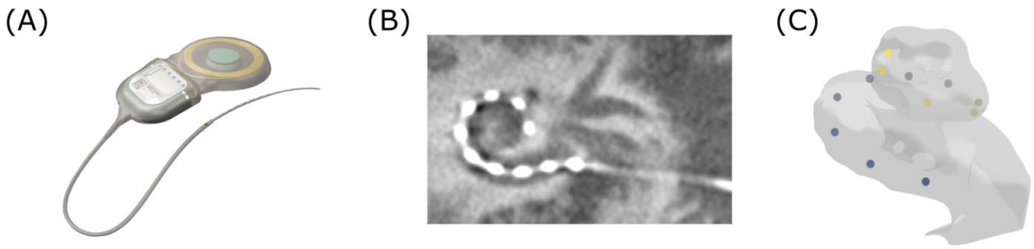

Abbildung 1: Figure: (A) Cochlear Implant (MED-EL, Austria) (B) Postoperative CT slice of the cochlear basal turn with CI electrodes (C) 3D visualization of the cochlea and electrode positions.

Your tasks

- Basic research (10%): Literature research is conducted on existing pre-trained models for brain and temporal bone CT scans, focusing on feature extraction and transfer learning. Explore how anatomical information from the inner ear can be better leveraged and encoded using domain-adapted models, multi-modal fusion strategies, and transformer-based architectures. Assess the potential of incorporating additional impedance- and image-based features.
- Algorithm development and experiments (70%): Based on the literature research and your ideas, you will implement suitable neural network architectures tailored for regression-based estimation of electrode positions. Emphasis will be placed on appropriate CT pre-processing pipelines and extracting meaningful, high-dimensional embeddings from image-based features. Training data consists of about 150 pre- and postoperative CT scans of the temporal bone, with labels of the electrodes and cochlea and impedance recordings from the implants.
- Results analysis (20%): Analysis of learned representations and feature interactions within the model. Evaluate regression performance against baseline multimodal models and classical machine learning methods. Emphasis will be placed on interpretability and understanding the contribution of different modalities and features to model predictions.

Your profile

- Master's student in the field of biomedical engineering, electrical engineering, computer science or a similar area
- Intermediate Python programming knowledge (PyTorch as a bonus)
- Strong motivation and scientific curiosity

References

- Schraivogel S, Weder S, Mantokoudis G, Caversaccio M, Wimmer W. "Predictive Models for Radiation-Free Localization of Cochlear Implants' Most Basal Electrode Using Impedance Telemetry." IEEE Transactions on Biomedical Engineering (2024). doi.org/10.1109/TBME.2024.3509527.
- Stahlschmidt SR, Ulfenborg B, and Synnergren J. "Multimodal Deep Learning for Biomedical Data Fusion: A Review." Briefings in Bioinformatics 23 (2022). doi.org/10.1093/bib/bbab569.
- Pai S, Hadzic I, Bontempi D, et al. "Vision Foundation Models for Computed Tomography." arXiv (2025). doi.org/10.48550/arXiv.2501.09001.

We offer

- Opportunity to engage in innovative clinical research as part of a young, welcoming, and interdisciplinary team
- Collaboration with experts from the Bern University Hospital, Switzerland
- Continuous supervision and mentorship on site for the whole duration of the project
- On-site or remote access to our research workstation for training and validation (CPU: AMD Ryzen Threadripper Pro 5955WX, 3x GPUs Nvidia RTX A5000, 512 GB RAM)
- Workspace at the Klinikum rechts der Isar at Max-Weber-Platz with good accessibility by public transportation

Application

If you're interested in the topic, don't hesitate to send us an email with your application documents (e.g., CV and transcript of records).

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