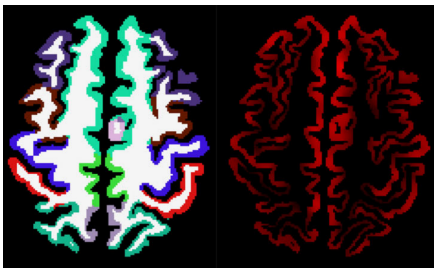


University Institute of Diagnostic and
Interventional Neuroradiology

Master's Thesis Proposal:
Evaluating and improving brain morphometry in MRI with dental braces

Brain morphometry is a computational method that enables statistical assessment of brain structure based on T1-weighted magnetic resonance imaging (MRI) by extracting variables like local cortical thickness, surface area, gyrification indices and the contrast between grey and white matter along the cortical band. Originally developed for scientific group studies, variants are more and more utilized also to support clinical diagnostics in individual patients.

Recently, we have developed Deep Learning (DL) based algorithms for brain segmentation and cortical thickness estimation. **DeepSCAN** (McKinley et al., 2021) segments healthy brain structures and lesions of patients with multiple sclerosis at the same time. This helped to reduce the false positive rate considerably and led to accuracies similar to inter-rater agreement of human experts. **DL+DiReCT** (Rebsamen et al., 2020) builds upon a variant of DeepSCAN and delivers cortical thickness within minutes (as opposed to hours). It also outperforms traditional software in terms of accuracy and within-subject reproducibility.

Adolescent patients often present with **dental braces** that cannot be removed for MR scanning. This introduces large **artifacts in frontal and temporal brain regions** and may seriously impair morphometry estimation in regions that are essential for epilepsy diagnostics. We have indications that DL-based approaches to brain segmentation and morphometry estimation might be better suited for these situations than traditional software, see Figure. The student will explore this clinically relevant situation and compare various methods. Segmentations provided by traditional and DL-based software will be inspected in detail and the reliability will be annotated on a voxel- and ROI-wise basis in frontal and temporal brain areas to investigate whether the region and level of compromise are indeed smaller with DL.

We also propose to **retrain** a variant of DeepSCAN by **adding augmented data**, with synthetically increased voxel intensity and reduced grey-white contrast in concentric frontal brain regions to mimic the effect of dental braces. DL+DiReCT will be run on these cases and its segmentations/parcellations will be used as input labels in a second pass. The limited amount of MRIs with real braces will be reserved for testing. If successful, this will enable more reliable morphometry estimation also in frontal and temporal brain regions.

The student's tasks are:

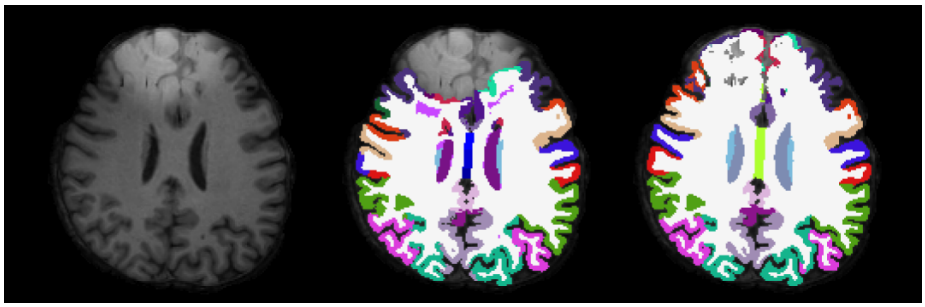
- review the literature on brain morphometry and DL
- extend training regime with data augmentation to simulate artifacts of dental braces
- Closely inspect segmentations on selected cases to assess reliability
- evaluate performance

Specific requirements:

- programming skills in Python
- skills in data engineering
- willingness to inspect and annotate data
- basics in Deep Learning
- basic statistics

Nature of the master thesis:

- literature study: 10%
- data annotation: 20%
- implementation: 20%
- data exploration: 30%
- documentation: 20%



T1-weighted MRI of an adolescent patient with signal alterations due to dental braces. Traditional segmentation software fails in the affected regions, whereas DL+DiReCT appears less affected.

References:

- McKinley R, Wepfer R, Aschwanden F, Grunder L, Muri R, Rummel C et al. (2021). Scientific Reports 11, 1087.
- Rebsamen M, Rummel C, Reyes M, Wiest R, McKinley R (2020). Hum Brain Mapp 41, 4804-4814.

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