BSc or MSc Project:
Segmentation and morphological comparison of distal radial articular surfaces

Abstract: Deep learning methods have revolutionized the field of medical imaging, in particular image segmentation. Supervised methods, often based on the popular U-Net architecture, show state-of-the-art results in many medical applications. But a large annotated database for training is not always available. Successful automatic segmentations can subsequently be used to analyze and compare the morphology of the anatomical structure in question.

In this project, we are interested in the human wrist. In particular, the aim is to verify the mirror symmetrical morphology of the distal radial articular surfaces. The overall clinical objective is to develop a patient-specific implant for destroyed surfaces of the distal radius due to secondary osteoarthritis after an accident. We have access to whole-body Computed Tomography (CT) in the shock room, where the goal is to extract the shape of the distal radii from the right and left hand and to assess their symmetry. So far, the assessment of symmetry has only been done using dicsrete manually placed landmarks [1].

Towards this aim, the objectives of this thesis are two-fold:

(i) to explore and develop learning-based methods for the localization and segmentation of the distal radii in whole-body CT using limited data, e.g., using transfer [2], or self-supervised learning [3, 4].

(ii) to compare and analyze the resulting surfaces using shape registration and deformation analysis [5, 6] similar to [7, 8].

The prospective student will explore existing deep-learning-based segmentation methods for training with limited data, and develop a framework to segment the distal radii and compare and analyze their shapes.

Requirements:

- Prior experience and good understanding in machine learning and statistics.
- Very good programming skills in Python (and PyTorch).
- Interest in medical imaging.

Contact:
Dr. Veronika Zimmer (veronika.zimmer@tum.de)
Prof. Julia Schnabel (julia.schnabel@helmholtz-muenchen.de)

References

[1] Gray, et al. "Image-based comparison between the bilateral symmetry of the distal radii through established measures." The Journal of hand surgery 44.11 (2019): 966-972.

[2] Cheplygina. "Cats or CAT scans: Transfer learning from natural or medical image source data sets?." Current Opinion in Biomedical Engineering 9: 21-27, 2019.

[3] Chen, et al. Self-supervised learning for medical image analysis using image context restoration. Medical image analysis, 58, 101539, 2019.

[4] Taleb, et al. "Multimodal self-supervised learning for medical image analysis." International Conference on Information Processing in Medical Imaging. Springer, Cham, 2021.

[5] Durrleman, et al. "Morphometry of anatomical shape complexes with dense deformations and sparse parameters." NeuroImage 101 (2014): 35-49.

[6] Bône, et al. "Deformetrica 4: an open-source software for statistical shape analysis." ShapeMI@MICCAI, 2018.

[7] Toussaint, et al. "A landmark-free morphometrics pipeline for high-resolution phenotyping: application to a mouse model of Down syndrome." Development 148.18 (2021):dev188631.

[8] Zimmer, et al. "Revisiting mandibular symphyseal shape in juvenile early hominins and modern humans using a deformation-based approach." (2022). https://doi.org/10.21203/rs.3.rs-1929855/v1