Master student project: Automatic bone, nerve and muscle segmentation from MR imaging of the lumbar spine

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Location: Balgrist University Hospital, Forchstrasse 340, 8008 Zurich
Project duration: 6 months
Project start: October 2023

Project Description:

Anatomical structure segmentation is essential for medical diagnosis. So far, most of this industrious work is done manually by trained professionals. Nonetheless, given variability between datasets and also the experience of the annotator, bias analysis is carried over the process.

With the emergence and wide applicability of deep learning algorithms from the artificial intelligence (AI) field, automatic segmentation of anatomical structures have gained momentum (Falk et al., 2019; Wasserthal et al., 2022). The current master thesis project aims at using currently open-source deep learning pipelines for image segmentation such as nnUNet and/or SAM (Isensee et al., 2021; Kirillov et al., 2023) for automatic segmentation of bone and soft tissue from magnetic resonance imaging (MRI) of the lumbar spine. Previously, MRI scans of the lumbar spine have been acquired. Afterwards, manual annotation of different anatomical structures, i.e., vertebrae, nerves and muscles was performed. This dataset, composed of high-quality MRIs and segmentations will be used for the development of a multi-structural segmentation model. For model development, both on-site and cloud computational resources will be available.

The project will initiate with a bibliographical review of the status-of-the-art of segmentation pipelines with a special focus on nnUNet and SAM (Falk et al., 2019; Isensee et al., 2021; Kirillov et al., 2023). Dataset preparation will follow together with implementation of the most suitable deep learning architecture and subsequent model training. The end goal of the project resides in the deployment of a multi-structural

segmentation model in a cloud setting powered by MONAI Label[1] and Slicer3D[2], allowing for direct visualization of the predicted segmentations of a given MRI dataset.

The DMU and ROCS teams are looking for a motivated master student with a background in biomedicine and/or computational sciences, good python scripting skills, knowledge in machine learning and interest in working at the interface between machine learning and medical applications.

For applications, please send your curriculum, course transcripts, and a letter of motivation to rui.ramos-santos@balgrist.ch together with the information of one reference contact.

References:

Falk, T., Mai, D., Bensch, R., Çiçek, Ö., Abdulkadir, A., Marrakchi, Y., Böhm, A., Deubner, J., Jäckel, Z., Seiwald, K., Dovzhenko, A., Tietz, O., Dal Bosco, C., Walsh, S., Saltukoglu, D., Tay, T.L., Prinz, M., Palme, K., Simons, M., Diester, I., Brox, T., Ronneberger, O., 2019. U-Net: deep learning for cell counting, detection, and morphometry. Nat. Methods 16, 67–70. https://doi.org/10.1038/s41592-018-0261-2

Isensee, F., Jaeger, P.F., Kohl, S.A.A., Petersen, J., Maier-Hein, K.H., 2021. nnU-Net: a self-configuring method for deep learning-based biomedical image segmentation. Nat. Methods 18, 203–211. https://doi.org/10.1038/s41592-020-01008-z

Kirillov, A., Mintun, E., Ravi, N., Mao, H., Rolland, C., Gustafson, L., Xiao, T., Whitehead, S., Berg, A.C., Lo, W.-Y., Dollár, P., Girshick, R., 2023. Segment Anything.

Wasserthal, J., Meyer, M., Breit, H.-C., Cyriac, J., Yang, S., Segeroth, M., 2022. TotalSegmentator: robust segmentation of 104 anatomical structures in CT images. https://doi.org/10.48550/arXiv.2208.05868

[1] https://monai.io/label.html

[2] https://www.slicer.org/