LMU KLINIKUM
Thoracic Imaging Group - Clinical Data Science
Klinik und Poliklinik für Radiologie

Master Thesis:
Robust deep-learning-based lung segmentation for stable quantitative imaging biomarkers

Background

At the department of radiology, the Clinical Data Science group (Prof. Dr. rer. nat. Michael Ingrisch) in collaboration with the DZL (German Center for Lung research) group for lung imaging (Prof. Dr. med. Julien Dinkel) is looking for a master's student. The research focus of this collaboration is the development and improvement of advanced machine learning/deep learning (DL)-based methods in lung imaging.

Project Outline

An essential step prior to (automated) lung image analysis is lung segmentation. Although a large selection of DL-based segmentation algorithms is available today (many of them open source), their performance on computed tomography (CT) images from clinical routine is often not reliable enough to be able to fully automatically extract stable quantitative imaging biomarkers (i.e., reproducible medical image features that can be used to e.g., train models supporting clinical decisions). Particularly challenging cases for lung segmentation in CT images are transplanted lungs.

The aim of the proposed master's project is to develop a new robustness score for lung segmentation based on the imaging properties of CT and to build a pipeline for robust automated segmentation and extraction of quantitative imaging biomarkers.

In the CT imaging procedure, a narrow beam of x-rays is aimed at a patient's body from different angles. The detected signals are processed using image reconstruction algorithms to generate cross-sectional grey-scale images of the internal body. Each voxel value (CT-value) of the resulting 3-D scan describes the attenuation of X-rays in the different tissue types (calibrated to water and air as reference values) and is given in Hounsfield units: CT-value (μ_{tissue}) = 1000 * (μ_{tissue} - μ_{water}) / (μ_{water} - μ_{air}). μ is the linear attenuation coefficient of the Beer–Lambert law that relates the attenuation of electromagnetic radiation to the properties of the material. Although μ is generally dependent of the specific molecular composition of the absorbing material, the relationship of HU values to mass density is often approximated to be linear. Based on this approximation we suggest, to develop a new robustness score for lung segmentation using the following idea: since the total mass of lung tissue in in- and exhale CT scans of a patient is constant, a perfect segmentation algorithm should yield the same "HU mass" (sum of HUs over all voxels within the lung segmentation mask) for both types of scans. Such a score promises to be human-reader independent, i.e., objective, as well as time- and cost-efficient, because no manual segmentations are needed as "ground truth". As a first task, the candidate will implement this "lung weight segmentation score" using expert manual segmentations of transplanted lungs in in- and exhale CT images, and thoroughly evaluate the validity of the linearity assumption by studying the physics that underlay the relationship between HU and the mass density within the CT lung window. Further errors originating from physiological effects and acquisition parameters will also be analyzed and quantified. Additionally, the theory behind the new score can be verified experimentally by acquiring in- and exhale CT scans on a lung phantom. After implementation, the new score will be tested for a selection of (open source) lung segmentation algorithms and compared to classical performance metrics. In a next step, the candidate will develop a robust lung segmentation model with focus on lung transplantation e.g., by improving existing algorithms and retraining. As a last step, a pipeline for automated segmentation and extraction of quantitative imaging biomarkers will be built, using standardized radiomic image features in order to characterize the lung transplantation cohort.

Your profile

- Highly motivated master student with a strong interest in deep learning and medical imaging (physics, computer science, data science or other natural sciences) / a master's thesis time frame of one year is preferred
- Scientific curiosity, creativity and a self-sufficient work attitude
- Experience in programming (preferably: Python) and basic knowledge of established deep-learning frameworks (preferably: Pytorch)
- Mandatory vaccination in healthcare: From 15.03.2022, all employees in hospitals will be subject to mandatory vaccination against SARS-CoV-2.

What we offer

- Development and implementation of innovative machine learning concepts with clinical real-world data; direct access to state-of-the-art computing infrastructure
- A unique, radiological lung transplantation imaging dataset
- Medical expertise through close collaboration with experienced radiologists
- Dynamic and exciting interdisciplinary working environment in the continuously growing group for Clinical Data Science in Radiology
- Extensive scientific and clinical track record in pulmonary imaging
- Excellent research environment in one of the largest university hospitals in Europe

If you are interested or wish to learn more about the project, please contact Dr. Katharina Jeblick (Katharina.Jeblick@med.uni-muenchen.de). Your email should include a short CV, relevant certificates, and a short cover letter. We are looking forward to getting to know you.