MASTER THESIS PROJECT in the Prof. COAN's LMU GROUP

'Brilliant X-Rays for Medical Diagnostics'

Our group at the LMU Chair of Medical Physics in Garching (LS Parodi) is working on biomedical applications of X-ray phase contrast CT and of novel imaging methods, and is looking for a highly motivated **MASTER STUDENT** to work with us. The group is affiliated to both the Department of Radiology/Medicine Faculty and the Department of Physics, of the LMU.

Project Title: "Study micro-morphological changes caused by a SARS-CoV-2 infection in the lung, brain and kidney tissues of COVID-19 patients by X-ray phase-contrast micro-CT"

Scientific Case: Fast and reliable triage of patients with suspected SARS-CoV-2 infection and COVID-19 pathology is crucial for the safety of patients and clinical staff. Given the difficulty of differentiating COVID-19 pneumonia from other atypical pneumonia by clinical chest CT, the collection of higher resolution data is necessary to reveal underlying discriminating morphological disease features, which may better inform future COVID-19 diagnoses. X-ray phase-contrast micro-CT (X-PCI-CT) is an emerging technique for non-destructive virtual histology, which is density-based, label-free and multiscale. It provides high degrees of morphological precision at organ-to-cellular scale, large sample coverage and high sensitivity, allowing the 3D visualization of both healthy and pathological soft tissues to answer different medical questions. For these reasons, X-PCI-CT is ideal for high-resolution volumetric analyses of different organs affected by COVID-19.

Experiments: Human lung tissues from healthy, influenza and COVID-19 affected patients will be issued from the Department of Pathology of the Ludwig-Maximilian-University (LMU) of Munich. Further human lungs from COVID-19 patients will be collected prospectively at the University of Uppsala (UU) together with portions of brain and kidney from the same patients. Standard clinical data (chest CTs, the main laboratory parameters, disease course, hemodynamics, respiratory mechanics) collected at the LMU and UU University hospitals on the patients from whom the tissues were extracted will be used for correlation with X-PCI-CT results. The propagation-based X-PCI-CT technique will be used with a multiscale setup affording voxel sizes in the range 27x27x27 – 2x2x2 μm^3. After the imaging sessions, specimens will be embedded in paraffin and analysed by histology and immunohistochemistry for correlation.

Overall Project Objectives: The objective of this project is to assess at high resolution the morphological organ- to cellular-level changes caused by a SARS-CoV-2 infection in the lung, brain and kidney tissues of COVID-19 patients. To this end, we propose to use X-ray phase-contrast micro-CT (X-PCI-CT) for a multiscale virtual-histological *post-mortem* 3D analysis of large dissected human organ samples. The primary goal is to use this imaging approach for the detection and characterization of SARS-CoV-2-driven lung pathology, including alveolitis, interstitial pneumonia and vasculitis. An imaging-based quantification of lung-tissue alveolar septal size and vascularization will be performed to compare X-PCI-CT results related to COVID-19 vs. influenza vs. healthy controls. Brain and kidney tissues from the same COVID-19 patients will also be screened via X-PCI-CT for signs of morphological damage.

Specific Thesis Work Objectives: Multiscale X-PCI-CT datasets will be reconstructed to derive 3D visualizations of lung, brain and kidney tissues, which will first be evaluated qualitatively and compared to histological findings. The CT image reconstruction will require the optimization of several parameters and the correction of possible artifacts related to the experimental setup and data acquisition procedure. The quantitative analysis of reconstructed phase-contrast CT datasets will be guided by the specific questions set by the medical partners. After segmentation of different anatomical structures (alveoli, cells, vasculature, lesions), key COVID-19-linked morphological organ features (alveolar size, septal vascularization, parenchyma lesions) will be quantified via appropriate (semi-)automatic algorithms and used for a comparative analysis. You will learn to reconstruct and explore the acquired phase-contrast CT datasets and extract meaningful structural parameters by segmentation and 3D visualization. You will learn to critically evaluate your analytic methods and explore new ways to use imaging datasets creatively. Your work will play a crucial role within this project, and will be instrumental to the successful publication of our results.

Candidate: Previous knowledge in Phython and/or Matlab could be an asset (but it is not mandatory), and the candidate should be interested in developing new analysis tools for image quantification.

Scientific and academic context: This Master project will be realized within an international framework involving medical doctors and physicists from the University Hospitals of the Ludwig Maximilians University (Germany), Uppsala University (Sweden) and Grenoble University (France) as well as scientists from the MAX-IV synchrotron in Lund (Sweden) and the European Synchrotron Radiation Facility (France). The student will work in a highly motivated and well established team within a multidisciplinary network embedded in a stimulating scientific environment with a long tradition of collaboration and excellence in biomedical research, with outstanding research and clinical infrastructures.

Start date: Flexible

Please get in contact with us if you are interested in knowing more - we would be happy to hear from you!

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