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Quantitative analysis of 3D lung image data at the micrometer scale

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With the advent of highly brilliant third-generation synchrotron X-ray sources in vivo imaging of biological samples has recently reached micrometer spatial and sub-second temporal resolutions. Analyzing high-resolution 3D biological structures such as lung tissue, however, still poses a great challenge due to its complexity and hierarchical branching scheme. In this work we demonstrate the application of quantitative tools for morphological and topological analyses applied to high-resolution murine 3D lung image data, inflated at different pressure levels under immediate post mortem conditions. We show how the tools might be used for a detailed description of lung inflation patterns, providing deeper insight into lungs physiology and opening a whole new range of applications. In particular, we observe first indications for heterogeneous intra-lobar and inter-lobar distension patterns and find no evidence for cyclic opening and closing of alveolar structures.

Summary

Here, I will present a full route to quantitative analysis of high-resolution 3D lung image data, starting from the image acquisition scheme for intact animals, how it particularly affects the segmentation and by making the link to quantitative 3D characterization of lung tissue. We employ local structural thickness analyses for assessing volumetric changes at various structural scales. For the topological analysis of the air-to-tissue surface in the lung, we apply the theory from differential geometry to calculate localized surface curvatures. We show for the first time the results of thickness map and curvature analyses performed on dose-efficient fast tomographic images of intact lungs.

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