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Abstract

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Investigating the lung with 3D images from light and electron microscopy

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The closer the look, the more complex are the structures of the lung and the more challenging become their analyses. New insights into the astonishing architecture and the complicated developmental dependencies are gained by pairing 3D imaging techniques based on light and electron microscopy. However, the resulting 3D images are very large (ranging from a few Gigabytes to a few Terabytes) and not easy to grasp neither visually nor analytically. Even though stereology can be employed to quantify aspects of these datasets, some questions can only be answered with 3D digital image processing. This often demands segmenting the structures of interest, like tissue, airspaces and blood vessels.

Manual segmentations are often regarded as the most reliable but are also most tedious and time-consuming to create. Methods exist that segment the data fully automated such as conventional image filters (e.g. watershed, level-sets, graph cuts) or machine learning (in particular Deep Learning, e.g. 3D U-Net, DeepMedic). However, fully automated segmentations without any manual intervention often yield results that do not represent the underlying anatomical structures sufficiently exact. It is possible to combine automation with manual interaction when segmenting the data. The automatic methods are chosen to produce multiple partial 3D segments that are then assigned manually to each structure of interest. This procedure can be a good trade-off between speed and exactness, ensuring that the final segmentation was thoroughly inspected visually.

These segmentations then not only enable to quantify simple measures like volume and surface area of the structures of interest but also diffusion distances, regions of supply and topological characterizations of the alveolar capillary network. Additionally, the segmentations allow sophisticated visualizations along extracted paths either for virtual endoscopy or for straightening the data.