Quantitative three-dimensional X-ray imaging

Philipp Schneider

Bioengineering Science Research Group, Faculty of Engineering and Physical Sciences, University of Southampton, Southampton, UK

High-Performance Vision Systems, Center for Vision, Automation and Control, AIT Austrian Institute of Technology, Vienna, Austria

Abstract. Living structures are an intricate three-dimensional arrangement of cells and tissue matrices. The structural analysis of tissues, however, generally remains constrained by microscopy of sparse two-dimensional sections, providing only a snapshot from which spatial relationships can be inferred. Image data is the prerequisite for quantifying the spatial organization and interrelation between anatomical structures in their native environment in order to understand their function. This talk will show the power of three-dimensional imaging to interrogate biological tissues with a special focus on micro computed tomography (μCT) in conjunction with advanced image processing & quantification. In the musculoskeletal field, research is geared towards a holistic understanding of bony tissue, considering the coupling between angiogenesis and osteogenesis. Therefore, we have implemented μCT and image processing for the simultaneous visualization and quantification of calcified bone and its intracortical vasculature, suggesting a sexually dimorphic regulation of the bone vascular network. We translated this framework to the field of paleontology to study cementum increments as a record of an animal's life history to overcome caveats of conventional cementochronology approaches [1] and further developed it for colonic crypts during the early stages of colorectal cancer [2]. We developed soft-tissue-optimized μCT for formalin-fixed, paraffin-embedded biopsy specimens beyond histology workflows to bridge the gap between biological and preclinical imaging [3], for which we have established a dedicated facility, see www.xrayhistology.org.

1. Newham et al.: *Journal of the Royal Society Interface*; 2020, 17:20200538. 10.1098/rsif.2020.0538, *Nature Communications*; 2020, 11:5121. 10.1038/s41467-020-18898-4, *PLoS One*; 2021, 16:e0249743. 10.1371/journal.pone.0249743

2. Rossides et al.: *Scientific Reports*; 2021, 11:14672. 10.1038/s41598-021-93184-x

3. Katsamenis et al.: *American Journal of Pathology*; 2019, 189:1608-20. 10.1016/j.ajpath.2019.05.004

Curriculum. Philipp Schneider studied physics at ETH Zurich. After his PhD in bioengineering, Philipp advanced high-resolution three-dimensional bone imaging and experimental mechanics at the Institute for Biomechanics of ETH Zürich. Currently, he is Full Professor of Biomedical Imaging at the University of Southampton, where he has been the Academic Director of the μ-VIS X-ray Imaging Centre (http://www.muvis.org) till 2021. His research team has developed and applied multi-scale and correlative biomedical imaging, undertaking translational efforts to integrate engineering knowledge into pre-clinical applications by high-resolution *in vivo* and *ex vivo* imaging. Prof. Schneider is the principal investigator of a Wellcome Trust-funded research program www.xrayhistolgy.org and co-investigator for the National Research Facility for Lab X-ray CT in the UK, see www.nxct.ac.uk. Since 2021, he has strategically led research in high-performance vision systems with a focus on high-speed sensing, AI-driven surface inspection, and three-dimensional measurement at the Austrian Institute of Technology.