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Machine learning for the generation of virtual histology images from X-ray phase contrast tomography of biodegradable metal bone implants

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Histology remains the gold standard for the visualization and study of biological tissue in clinical pathology and biomedical research. However, the typical workflow entails time-consuming sample preparation steps whereby the tissue is first fixed, embedded and sectioned into slices before chemical staining, after which each slice is individually scanned by optical microscope. In comparison, synchrotron x-ray phase contrast (PC) tomography can be performed on the same subject material without the need for staining or sectioning, allowing for the simultaneous acquisition of data across the full sample volume that can be virtually sliced in any plane. This project examines the transformative potential of machine-learning techniques to combine the experimental efficiency of x-ray tomography with a synthesized image contrast that is characteristic of histological staining, a so-called virtual histology. At the Helmholtz-Zentrum Hereon (with research outstation based at the DESY campus in Hamburg, and beamlines and laboratories hosted by the Hereon Institute of Materials Physics), the Institute of Metallic Biomaterials is working on the study and development of biodegradable magnesium alloys as bone implant material. In those studies a suite of multi-modal imaging techniques over a wide range of scale have been utilized. For the training of our GAN neural network, over 30 data set pairs of both CT and then histology measurements performed on the same murine bone implant samples have been carefully co-registered through the development of our in-house 3D-2D multimodal registration software. Here we would like to present preliminary results of this project and discuss various aspects of the training requirements, our model assumptions and key pre-processing steps noted thus far.

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