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Experimental design for X-Ray phase-contrast microtomography of breast samples for virtual histology

The small difference in X-ray attenuation properties of tumor and normal breast tissue demands for X-ray breast imaging techniques that deliver high contrast, high spatial resolution images acquired at a low dose. Previous studies [1-3] have shown the potential usefulness of 3D phase-contrast micro-tomography (micro-CT) imaging as an adjunct tool to conventional histological techniques. We present a methodology to deliver micro-CT images of breast tissue specimens to accompany current histological examinations.
Tomographic acquisitions of three paraffin-embedded breast tissue samples with a polychromatic synchrotron beam (average energy~24 keV) were carried out at the SYRMEP beamline of Elettra, the Italian Synchrotron facility in Trieste. Phase-contrast tomography can deliver a considerable gain in signal-to-noise ratio (SNR) at small pixel sizes when it is combined with the free-space propagation technique and a suitable phase retrieval filter [4]. In this study, the pixel size was adjusted to 1, 2.5 and 4 micrometers and the sample-to-detector distances of 150, 250 and 500 mm were used.
We performed micro-CT scans of the areas with histological features of interest of the breast specimens by acquiring 1800 evenly spaced projections over a 180-degree angle at a fixed source-to-sample distance of 22.3 meters for each pixel size. Micro-CT reconstructions were then compared with their respective histological images. We found a very good match between the techniques. The combination of the free-space propagation phase-contrast technique and the phase-retrieval algorithm resulted in better quality images than in conventional x-ray imaging, showing an excellent visibility of the samples' structural features. These structures can undergo alterations in pathological processes of benign and malignant origin. Recognition of these components could provide additional information and important feedback to the pathologist in the evaluation of tumor architecture.

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