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Quantitative Reconstruction of an Arbitrary Sample using Propagation-Based Phase-Contrast X-ray Imaging

S. J. Alloo[1], D. M. Paganin[2], K. S. Morgan[2], M. J. Kitchen[2, 3], L. C. P. Croton[2], and K. M. Pavlov[1, 2, 4].

1. School of Physical and Chemical Sciences, University of Canterbury, Christchurch, New Zealand
2. School of Physics and Astronomy, Monash University, Victoria, Australia
3. Ritchie Centre, Hudson Institute of Medical Research, Clayton, Victoria, Australia
4. School of Science and Technology, University of New England, Armidale, Australia

We have developed an algorithm [1] capable of quantitatively extracting both components of a sample's refractive index distribution. In X-ray imaging, materials are characterised by their complex refractive index, $n(\boldsymbol{r}) = 1 + \delta(\boldsymbol{r}) - i\beta(\boldsymbol{r})$, as it describes X-ray behaviour within the material. Our approach does not require any *a priori* sample information, and although initially derived for X-rays that are monochromatic plane-waves, we demonstrate that it can be extended to consider polychromatic cone-beams.

Propagation-based phase-contrast X-ray imaging (PB-PCXI) is an experimentally simple technique capable of reconstructing high-resolution images of weakly-attenuating objects—for example, biological tissues, at a low sample absorbed dose [2]. Our approach [1] exploits Fresnel fringes, formed in PB-PCXI, to reconstruct sample refraction, $\delta(\boldsymbol{r})$, and attenuation, $\beta(\boldsymbol{r})$, information. The method is based on curve-fitting error functions across distinct interfaces within a tomographic axial slice of the object. The fit parameters are then used to uniquely calculate $\delta(\boldsymbol{r})$ and $\beta(\boldsymbol{r})$ for composite materials. We applied this approach to PB-PCXI data, collected at a Monash University laboratory, of a grub (see Fig. 1). For an unknown biological medium, it is standard to assume the medium is made from water. The proposed technique provides a more realistic value based on measurements of the data, which for the grub was 9.5% off the water value estimate.

Current PB-PCXI phase-retrieval algorithms typically require *a priori* sample information, namely $\gamma = \delta/\beta$, to accurately reconstruct phase-contrast images [3, 4, 5, 6]. An incorrect γ value results in sample boundaries being over- or under-smoothed. Our approach [1] extracts a reliable value of γ, which can be used in already well-established PB-PCXI algorithms [3, 4, 5, 6] to obtain optimal reconstructions. Material boundaries in the resultant tomographic slice would not be over- or under-smoothed, which is important in, for example, radiation treatment planning. The approach can also be used within diagnostics, as it reveals a refined and complete sample description.

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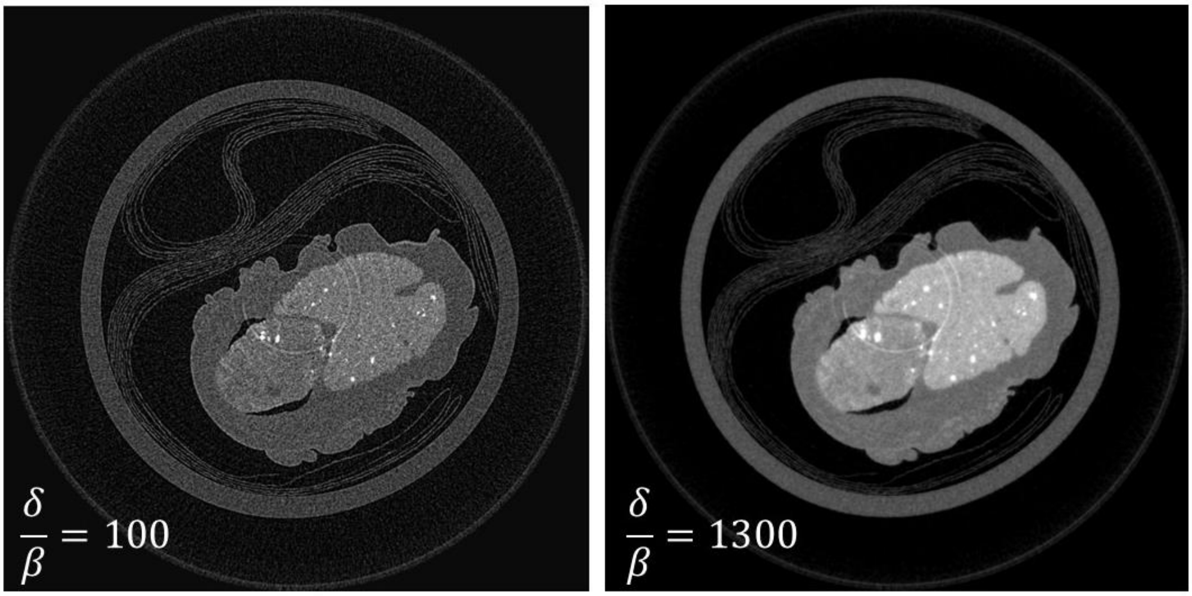

Figure 1: PB-PCXI computed tomographic axial slices of the grub data. Both CT slices have been phase-retrieved using Paganin et al.'s [3] single material approach with (left) δ/β=100 and (right) δ/β=1300. δ/β=1300 is the optimal value for the grub, extracted using the proposed approach [1].