Image Reconstruction in X-Ray Phase-Contrast Tomography

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Abstract

X-ray phase-contrast imaging is a technique that aims to reconstruct the projected absorption and refractive index distributions of an object. This can be accomplished by employing independent intensity measurements (i.e., phase-contrast radiographs) acquired at distinct measurement states. Quantitative phase-contrast imaging methods are computed-imaging methods and require the application of reconstruction algorithms for image formation. However, one common feature of these reconstruction formulas is the presence of isolated Fourier domain singularities, which can greatly amplify the noise levels in the estimated Fourier domain and lead to noisy and/or distorted images in spatial domain. In this article, we develop a statistically optimal reconstruction method that employs multiple (> 2) measurement states to mitigate the noise amplification effects due to singularities in the reconstruction formula. Linear estimators are proposed to combine the available intensity measurements in such a way that the poles present in estimates obtained by use of any two measurements are canceled. Computer-simulation studies are carried out to quantitatively and systematically investigate the developed method, within the context of propagation-based X-ray phase-contrast imaging. The reconstructed images are shown to possess dramatically reduced noise levels and greatly enhanced imaging contrast.