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Coupled Holo-Tomography: Improved 3D Object Reconstruction

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Near-field inline holography enables imaging of microscopic objects, including biological specimens, offering rapid data acquisition based on full-field imaging. Object-induced phase shifts on a coherent illumination are encoded in interference patterns at the detector. Its intensity distribution is recorded in a hologram. However, the reconstruction of the phase shift from the (single-projection) hologram forms an ill-posed inverse problem and requires iterative phase retrieval. In holo-tomography, holograms are acquired at multiple angles under a 180° rotation to access the internal structure.

In conventional holo-tomography reconstruction, holograms are intensity-corrected for the illumination through flat-field correction. Phase shifts for all angles are calculated using an iterative phase retrieval algorithm, and cross-sections of the reconstructed object are determined via inverse Radon-transform. To improve the reconstruction quality, we propose the following coupled holo-tomography approach. Complex phase shifts are retrieved by simultaneously correcting for the complex illumination function, effectively removing any distortions stemming from the illumination. After a few iterations of phase retrieval, a preliminary tomogram is determined, supplemented with a loose support constraint to suppress reconstruction artifacts. From this first tomogram, updated projections are calculated and serve as an updated guess for further phase retrieval. By alternating between phase retrieval and the tomographic reconstruction, we obtain an improved 3D reconstruction in comparison to applying only one tomographic step consecutive to phase retrieval, and an artifact-free object is enforced through tomographic consistency through the data set.

This approach improves the holo-tomographic reconstruction by correcting for a complex illumination, reducing reconstruction artifacts and improving phase retrieval by updating its estimations from tomographic reconstruction projections. Simulation results, based on a 3D object consisting of strong induced phase-shifts and sharp edges, emphasise the efficiency of coupled holo-tomography compared to the standard approach. Our coupled holo-tomography approach promises significant improvements in the 3D object reconstruction for X-ray near-field holo-tomography experiments.

I plan to submit also conference proceedings

No

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