Contribution ID: **527** Type: **Contributed talk**

High-Resolution Phase-Contrast Imaging for Large Samples at Synchrotron Sources with Time-Varying Beam Profiles

Friday 30 August 2024 12:15 (15 minutes)

One recently introduced method for the exploration of biological specimens and material structure using phase-contrast imaging combines a Talbot Array Illuminator with the UMPA method of phase retrieval [1]. This method has been shown to enable exceptionally high bidirectional sensitivity and high-resolution imaging without requiring prior assumptions about the sample's composition [2]. However, time-dependent variations in the beam profile at synchrotron sources, often caused by movements within the beamline components, the top-up mode of operation, or orbit control of the electron beam, pose significant challenges. These variations can lead to discrepancies between the flat field images captured before the scan and the actual flat field present during the recording of the sample projections. Consequently, structures such as grating patterns or sandpaper textures, used as wavefront markers, are left visible in the flatfield-corrected images, compromising image quality and quantitative accuracy.
Recently, the eigenflat-optimization approach has been developed to address this issue by decomposing a group of recorded flatfields into eigencomponents and fitting a combination of them to the sample projection using a sample-free region [3]. The method is effective for smaller specimens but falls short when imaging larger samples using multiple views stitched together. While the leftmost and rightmost views have an empty reference area, this is not the case for the middle views, where the sample covers the entire field of view – a problem also encountered in scans focused on specific regions of interest. In both scenarios, the original eigenflat method is not applicable, and artifacts degrade the image quality. In response to this limitation, we introduce a novel approach that extends the capabilities of eigenflat-optimization to accommodate larger samples without the necessity of an empty reference region. By using a new approach for the optimization step, our method generates eigenflat weights for the central portions of the sample, thus enabling the seamless stitching of multiple views and enhancing the overall image quality. This approach allowed us to record a high-resolution image of a full rat brain, 15 mm in diameter, at beamline P07 –operated by Hereon –at PETRA III (DESY, Hamburg), despite the limited 6 mm horizontal field of view. Furthermore, we have incorporated deformable registration techniques to refine the alignment and overlay of partial scans, thereby better compensating for sample deformation caused by radiation damage and detector distortion. Consequently, our method offers a robust solution to the challenges posed in investigating large samples at synchrotron sources.

I plan to submit also conference proceedings

No

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Session Classification: Mikrosymposium 3/3: Data, Automation and the Use of AI

Track Classification: 3. Data, Automation and the Use of AI