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Reconstruction with correction for rotation-axis and illumination fluctuation in phase contrast nano-CT

In *computerized tomography (CT)* the measurement process can be modeled using the Radon transform, which maps the unknown material density to the corresponding absorption loss.

In *Nano-CT* the scale is so small that even movements of the measuring apparatus lead to *unwanted rigid movement* of the scanned object. Ignoring this and just building the linear radon operator $A^{\gamma_0} : X \to Y$ with the assumed motion γ_0 leads to artifacts in the reconstruction. The true motion $\gamma^\dagger$ is not known, i.e. we can not construct the correct linear Radon operator $A^{\gamma^\dagger} : X \to Y$ and have to put the motion $\gamma \in \Gamma$ as to be determent parameters $A : X \times \Gamma \to Y$.

Furthermore we are interested X-ray phase contrast. This can also be modeled using the Radon transform, but the phase information can not be measured and needs to be computed first. This *phase retrieval* leads to *artifacts* of its own, partially due to fluctuations in the illumination. In conclusion, the input *data* is *misaligned* and has *background artifacts*. Both need to be addressed for sufficient image quality.

The currently used *re-projection alignment algorithm* uses re-projected filtered back projections and image registration to reconstruct shift and object. We *improve* on the algorithm by using a thresholded version of normalized cross correlation for the *image registration* and imposing *additional constraints*, specifically a non-negativity constraint on the object, smoothness on movement and taking the uncertainty in low frequencies due background data artifacts into account.

We illustrate the algorithm on measurements of nano-porous glass. The data was recorded at the Göttinger Instrument for Nano-Imaging with X-rays (GINIX) *operated by the Salditt group (University of Göttingen)* located at the P10 beamline at the PETRA III storage ring at DESY in Hamburg.

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