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Multi-Scale Three-Dimensional Reconstruction of Ptychographic X-Ray Tomography Data

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Introduction

Ability to image volumetric structure of nano/microscale systems in material science brings a better understanding of the structure-function correlations that can significantly increase their performance in applied fields. Direct 3D reconstruction from coherent diffraction X-ray imaging (CDI) data requires large computational recourses. Therefore, we present here a multi-scale approach for reducing convergence time by fast reconstruction of low-resolution image and its further application as an input guess for high-resolution reconstruction.

Coherent X-ray diffraction imaging

In CDI experiment an incident wave interacts with a sample experiencing refraction and attenuation and propagates into a far-field detector that measures its intensity given by

$$ I \equiv |\mathcal{F}\{P \ast \exp\{ik|n-1\}\}|^2 $$

where $P$ is illumination function, $n$ is complex refractive index of the sample (object function) and $\mathcal{F}$ is Fourier transformation.

**Figure 1:** Schematic of ptychographic CDI.

Phase-retrieval algorithm

Reconstruction of the sample can be formulated as a least-squares optimization problem solved by iterative minimization of the difference between measured and approximated diffraction intensities:

$$ \min_{x} (I^m - I^{\text{exp}}) $$

Complex valued object function and squared modulus operation in the expression for intensity make the problem ill-posed and non-linear. Here, we use Levenberg-Marquardt algorithm (LMA) in combination with conjugate gradient method (CGM) to find the optimal solution.

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**References**