Development of Low Dose Tomography Algorithms for 3D Imaging Using Neural Networks

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Electron microscopy of sensitive materials is restricted to very low electron doses, which severely limits the maximum number of available images. To produce meaningful tomographic reconstructions under these conditions, the study introduces NN-FBP(1), a new low-dose tomography algorithm that merges traditional Filtered Back Projection (FBP) with neural networks to enable high-quality 3D imaging from sparse data. The process begins with a forward projection of a-priori known molecular structures to establish a training dataset consisting of a tilting series of projections and corresponding 3D volume representations. This dataset is used to train a neural network, which learns to reconstruct volumes from a few projections. Formally, the learning process is described by a complex matrix equation linking image pixels of the tilt series to intensity voxels in the 3D dataset. The learning involves adapting a large number of fitting parameters in this equation. NNFBP incorporates elements of FBP to maintain computational efficiency and leverages its learning capability to adapt autonomously to various imaging scenarios. This flexibility makes it particularly effective for imaging electron beam-sensitive materials, minimizing exposure and preserving material structure. The method is demonstrated with experimental examples of metalorganic frameworks (UiO-67), showcasing its potential for high-quality 3D imaging of beam-sensitive materials. This marks a significant advancement in tomographic algorithms and positions NN-FBP as a highly promising tool for future 3D imaging applications, especially tailored for COFs and MOFs in research.

[1] D. M. Pelt and K. J. Batenburg: "Fast Tomographic Reconstruction From Limited Data Using Artificial Neural Networks," in IEEE Transactions on Image Processing, vol. 22, no. 12, pp. 5238-5251, Dec. 2013 DOI: 10.1109/TIP.2013.2283142,.