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IT-5-P-3319 Improvement of EFTEM acquisition and data processing using prior knowledge of camera DQE

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In transmission electron microscopy (TEM), electrons are traditionally detected using a camera with either indirect or indirect detection. In both cases the “true” image is degraded by the non-ideal point spread function (PSF) of the detector leading to a blurring of the signal and the addition of stochastic noise components such as dark-current noise or readout-noise.

Detector performances can be assessed by the measurement of the modulation transfer function (MTF), the noise power spectrum (NPS) and the detective quantum efficiency (DQE) [1,2]. First of all, it allows us to verify the specifications provided by the manufacturers, to compare the relative performance of different detectors and to estimate their degradation over time. Secondly it can help to optimize the acquisition strategy for a given problem. Finally this information can be used as prior knowledge for data processing algorithms.

Energy filtered transmission electron microscopy (EFTEM) has been used to illustrate the benefits of the knowledge of the characteristics of the detection system. Images corresponding to different energy losses are sequentially recorded on the camera device, resulting in a 3D dataset for which each image plane is convolved with the PSF of the camera and each spectrum with the resolution response function of the spectrometer.

This works aims in a first step to measure the DQE of the Gatan US1000 camera used in our JEOL 2200FS microscope in order to improve our EFTEM acquisitions. The recently developed silhouette method [2] is used for the determination of the MTF. In a seconds step this works tries to apply principal component analysis [3,4] in order to perform the denoising of the data as well as the improvement of its spatial or spectral resolution by deconvolution techniques. The prior knowledge of the noise model and the MTF of the camera are embedded in the deconvolution algorithms in order to perform the regularization of the solutions in a realistic way.

The data processing procedure is demonstrated on a simulated dataset providing a ground truth for exploring the applications, limits and eventual pitfalls of the algorithms under known noise levels and MTF. After the measurement of the camera characteristics, acquisition parameters required for a good signal-to-noise ratio are optimized. The algorithms are then applied to the real datasets.

References:

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[3] G. Lucas et al, Micron 52-53 (2013) p. 49-56.
[4] Multivariate Statistical Analysis plugin for Digital Micrograph™, lsme.epfl.ch/msa.