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Fast Automatic Point Spread Function Deconvolution Using Edge Detection

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Point Spread Function Deconvolution (PSFD) in electron microscopy has proved challenging and lagged behind similar work in optical microscopy until advances to the field by William E Vanderlinde [1] and Eric Lifshin [2] and others over the last 20 years pushed the process forward. In this work we propose and compare an alternative method for acquiring these Point Spread Functions (PSF).

Acquisition of the PSF can be an involved process in electron microscopy, often utilizing specific calibration samples and involved processes. This is undesirable as the PSF can change while the instrument is in use and changes can be an indication of poor instrument health such as a filament reaching end of life. With large image montages becoming more and more common and desirable, a shift in the PSF during a longer automated montage acquisition would result in a traditional PSFD being unable to be performed at all. Therefore, it is desirable to have a method that can perform either a blind or semi-blind extraction of the PSF during acquisitions.

By utilizing the mathematical relationship between the point spread, line spread, and edge spread functions in conjunction with edge detection and feature extraction from the field of machine learning and computer vision image processing [3], we can derive an estimated non-symmetric PSF from arbitrary samples given a sufficient amount of image contrast. First edges are detected that are suitable for edge spread function extraction (Figure 1: a, b, c) and then correlated and scaled to produce a PSF kernel. Additionally, by utilizing denoising processes in tandem with PSFD we are able to dramatically reduce the mottling effects often encountered when performing Richardson-Lucy [4, 5], Landweber [6], or Tikhonov [7] PSFD (Figure 1: d, e, f).

Due to the speed at which this method can be performed and the simplicity of its operation, it is possible to recompute this kernel for every image as they are acquired. By evaluating changes in the kernel the software can provide feedback to automated acquisition systems to inform the user or routine if a long montage or delayering process is drifting out of specified tolerances [9].

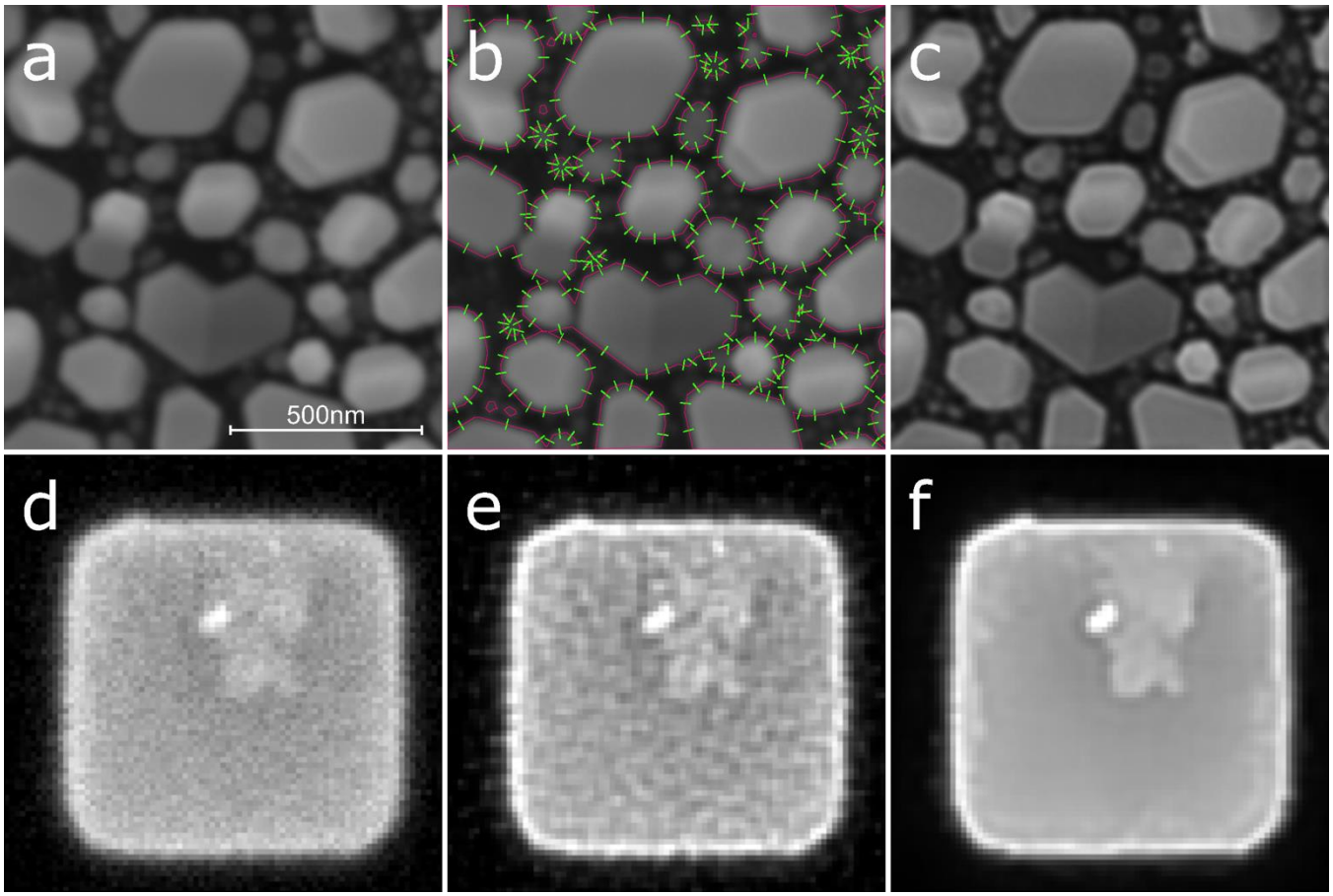

Figure 1: (Top) Gold on Carbon Micrograph from Kandel et al. [8] (a) original; (b) extracted edges and subset of transects used to derive edge spread functions; (c) result reconstructed using PSFD method described in this work. (Bottom) Micro Pillar Micrograph (a) original; (b) result reconstructed using PSFD methods without noise filtering; (c) result reconstructed using PSFD methods with noise filtering.

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