Resolution estimation of real sample images

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Image resolvability is the primary concern in microscopy. The spatial resolution of microscopic images depends not only on the microscope specifications, but also on many other factors including the ambient environment and the sample itself. We report here a method for estimating the resolution from real sample images [1].

In electron microscopy, Fourier ring/shell correlation has been used to estimate the sample image resolution [2]. Another method to estimate the resolution is to find a high-resolution limit in the frequency domain profile [3]. However, these methods rely on human-defined cutoffs, and hence involve arbitrariness in their nature.

The image resolvability is ascribable to the width of the point spread function (PSF) constituting the image. Therefore, the resolution can be determined from the PSF without defining any cutoffs. We have recently reported a method for extracting the PSF profile regardless of image types [1,4]. If we assume a Gaussian PSF, the logarithmic square norm of the Fourier transform $F(\mathbf{k})$ of the image is proportional to the square distance from the origin [1]:

$$\ln|F(\mathbf{k})|^2 = -4\pi^2\sigma^2|\mathbf{k}|^2 + \text{constant},$$

where $\mathbf{k}$ is the Fourier domain coordinate and σ is the standard deviation of the Gaussian PSF.

Figure 1a-c shows electron microscopic images of myelinated axons of a mouse brain. The original image was convolved with Gaussians having full width at half maximums (FWHM) of 2, 4, and 6 pixels. Bar patterns embedded in the images indicated that blurring corresponding to the Gaussian FWHM was introduced. The resolutions of these images were evaluated on logarithmic intensity plots [1,4] made using the RecView software (https://mizutanilab.github.io/). The obtained plots showed linear correlations proportional to squares of the FWHM (Figure 1d-f), indicating that the resolution can be determined with this method. A linear correlation was observed regardless of the image type, even using a cell phone picture [1] and a satellite image [4]. We suggest that this method can be an alternative measure of the spatial resolution that is independent of the imaging modality.

1. R. Mizutani et al., J. Microsc. 261 (2016) 57

2. W.O. Saxton & W. Baumeister, J. Microsc.127 (1982) 127

3. C. Jacobsen et al., J. Opt. Soc. Am. A 7 (1990) 1847

4. R. Mizutani et al., AIP Conf. Proc. (2017) in press

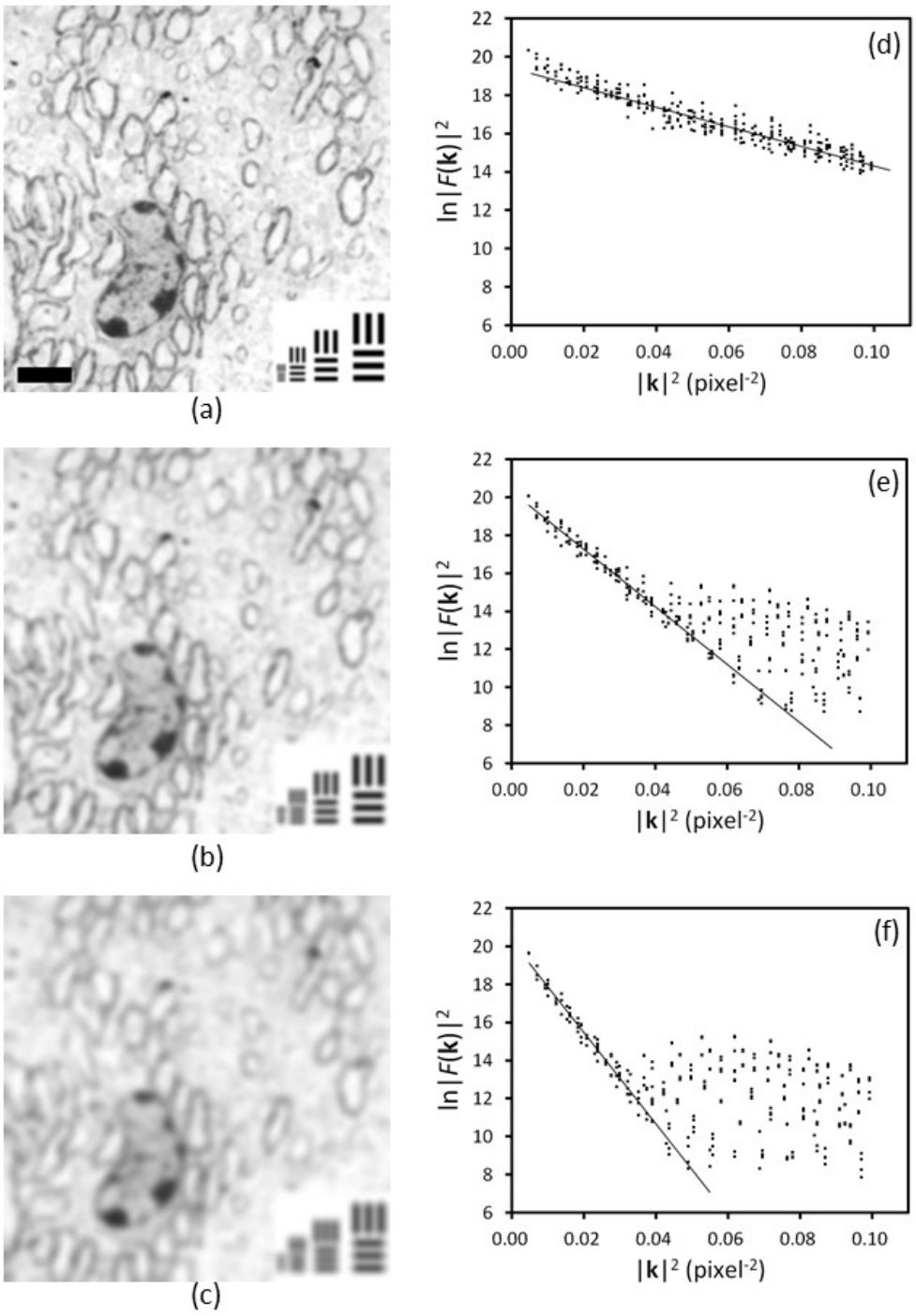

Figure 1. An electron microscopic image of myelinated axons of a mouse brain was convolved with Gaussians having FWHM of (a) 2 pixels, (b) 4 pixels, and (c) 6 pixels. Bar patterns with 2, 4, 6, and 8 pixel pitches indicated corresponding blurring was introduced. Scale bar: 2 μm. The resolutions of these images were evaluated on logarithmic intensity plots (d-f). The obtained plots showed linear correlations proportional to squares of the FWHM.