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Revised Algorithm for Image Sharpness Measurement in Scanning Electron Microscopy Based on Derivative Method in ISO/TS 24597 Document

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A standard method of evaluating the resolution, a key performance metric of SEM, is to determine the sharpness of gold-on-carbon sample image. There are several methods of the sharpness calculation, including Fourier transform method, contrast-gradient method and derivative method [1].

In the last conference, we reported our implementation of the derivative method as stated in ISO/TS 24596 to calculate the sharpness of (SEM) image [2]. Since then we have examined the assumptions, calculation process, and compatibility issues, while revising the algorithm.

Excluding the discussion over whether the edges of gold particles really represent the ideal on/off boundary, we found out additional restrictions need to be imposed for improved compatibility, even when we use the same method of the evaluation. Two key issues are:

First, the data length of the edge directional lines for fit to the error function should be adaptively controlled to maintain the fitting accuracy. Otherwise, different image magnification results in different sharpness, that is, higher magnification may estimate better sharpness than lower magnification. We updated WISE-FDL (fixed data length) to WISE-VDL(variable data length) to resolve this, which uses the data length varying according to the image sharpness (Figure 1). The magnification of the image is recommended to be large enough so that the adjacent pixels do not overlap each other.

Secondly, we note that the found sigmas (a measure of edge widths) has non-negligible variance, and only of the partial component comes from intensity profile of the electron probe. It thus seems to be reasonable to use the best sigmas to evaluate the image sharpness. How the best sigmas are selected, however, significantly impacts the results (Figure 2). Only when the percentage of the best sigmas are fixed, the evaluations can be compared directly. The statement of the variance as well as the mean of the sharpness may be cecessary, since it indicates other factors like the sample conditions.

Finally, graphical user interface version of the current matlab-based program is under development before uploading on the homepage so that the users are accurately guided and can easily control themselves the parameters that can impact the results [3].

References:

[1] Microbeam analysis - Scanning electron microscopy - Methods of evaluating image sharpness (2011) ISO/TS 24597.
[2] S. Kim *et al*, Microsc. Microanal. **22(S3)** (2017), p. 628.
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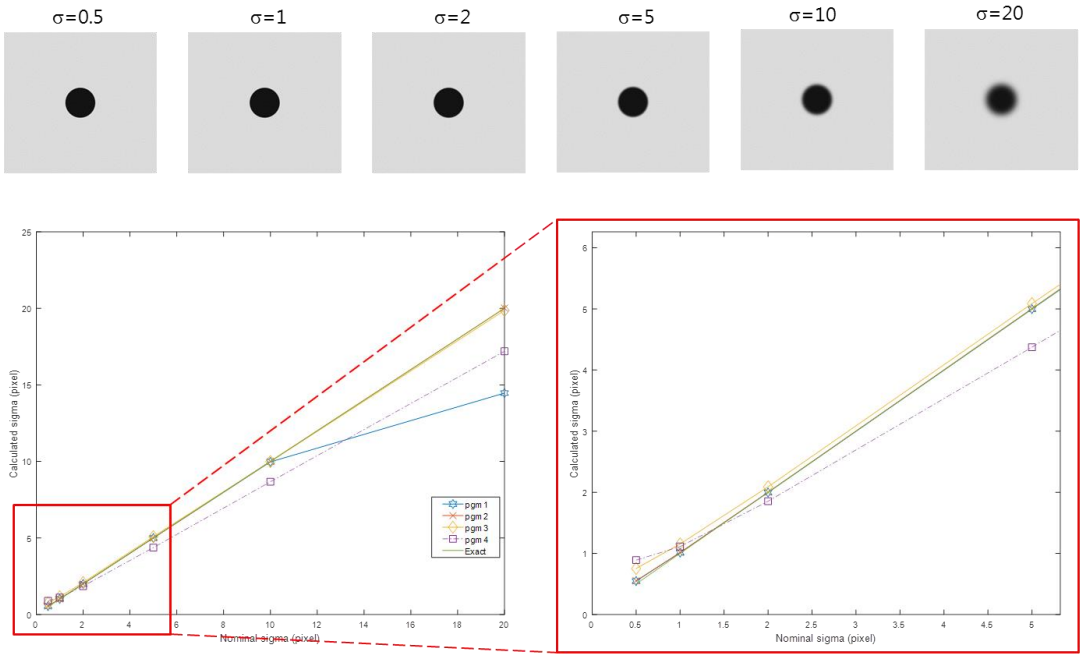

Figure 1. The effect of image magnification on the calculation of image sharpness is examined for the four available programs. For example, WISE-FDL(pgm1) is dependent of the sharpness value in pixels, while WISE-VDL(pgm2) is independent.

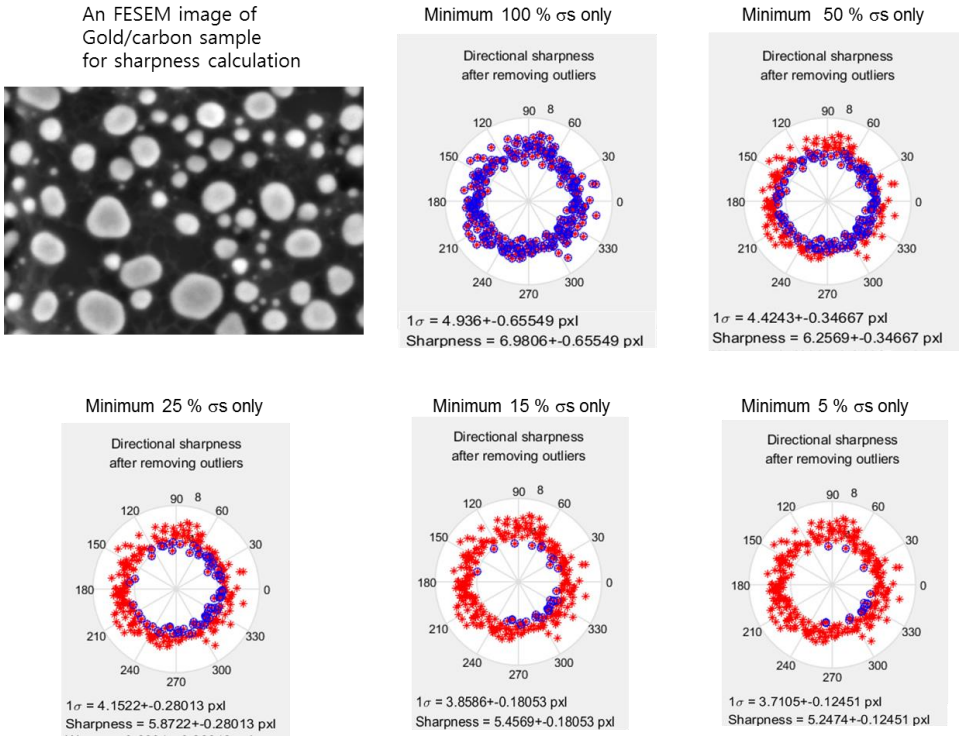

Figure 2. The effect of participating σs in the sharpness determination. Among the selected σs (red asterisk), only the best σs (red asterisk in the blue circle) are considered in the sharpness determination.

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