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NOISE LIMITS CONDITION FOR IMAGE CORRECTION IN SOFT X-RAY PROJECTION MICROSCOPY

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1 Introduction

In our study of soft X-ray projection microscope, to improve the effectiveness of image correction, we evaluated the influence of background noise in the iteration procedure through simulation study. In the simulation study, images of a model specimen with known morphology were used as a substitute for the chromosome images taken at BL-11A beamline. Under the condition that artificial noise was distributed on the images randomly, we introduced two different parameters to evaluate noise effects according to each situation where the iteration procedure was not successful, and proposed an upper limit of the noise within which the effective iteration procedure for the chromosome images was possible.

2 Experiment

Relationship between contrast of target in the corrected image and noise MSE (Mean Square Error) on the simulated projection image was examined for model specimens with small (0.7 μm) and large (1.4 μm) square sizes. The result is shown in Fig. 1. The horizontal axis is noise MSE on the simulated projection image and the vertical axis is the contrast of the target on the corrected image which was evaluated by the equation (1).

$$\text{Contrast of target} = |G_1 - G_2|/G_{max} \qquad (1)$$

where, G_1 is an average value of the grayscale distribution around the target in an area between the large square and the small square. G_2 is an average value of the grayscale distributions on the target in the small square. G_{max} ($=2^{16}$), 16 bit depth, is maximum value of the grayscale. "O" and "X" characters show correctable and uncorrectable region of noise MSE, respectively. "A" indicates the contrast and noise MSE of the current experimental image. Noise MSE of $>10^5$ decreases the contrast of target steeply, and it should not exceed 10^5.

Some representative images with high and low noise MSE are shown in Fig. 2 for the large specimens. In the figures, the simulated projection images and their corrected images are shown in the left and the right sides, respectively. Both images are shown for varying noise MSE ranging from $4*10^5$ to $4*10^6$. The background noise on the simulated projection images was prominent or inconspicuous for the images with high (10^6 and $4*10^6$) or low noise MSE ($4*10^4$ and 10^5), respectively. For the corrected image with high noise MSE, the contrast of the specimen image was lost by iteration procedure, resulting in inability to identify its morphology.

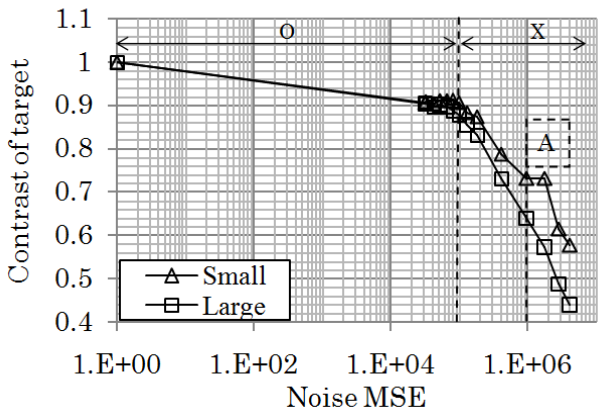

Fig. 1: Relationship between noise MSE of projection image and contrast of target in corrected image.

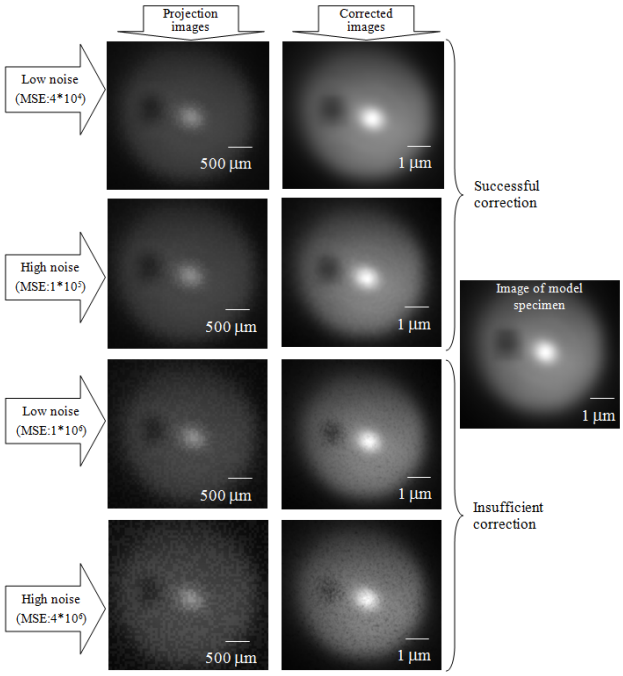

Fig. 2:Iteration effects on the projection images with very low contrast (large 1.4 μm square size).

References

[1] T. Shiina et al., PF Activity Report 2015 #33 B (2016). http://pfwww.kek.jp/acr/2015pdf/part_b/pf15b0363.pdf

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