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Improved Iteration Procedure with Noise Reduction on Image Correction for Soft X-ray Projection Microscopy

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1 Introduction

Projection soft X-ray microscopy has been studied during a decade and gradually improved its coverage to biological specimens. The current problem is the correction of low-contrast images. Especially, when the magnification increases, the contrast of a target image decreases. In the last year, we reported the contrast enhancement for the less-contrast image of chromosome up to the magnification of 219 [1]. In this study, the noise reduction by median filter was applied to the image correction procedure. To apply it, we estimated the noise level quantitatively and simulated the effect of the noise reduction. As a result, the improved correction procedure successfully expanded its coverage up to the magnification of 329.

2 Improved iteration procedure

Images of projection soft X-ray microscopy are blurred because of beam diffraction by a target. It is theoretically calculated in principle, while the amplitude information is only detected at the CCD screen. The phase information is assumed spherical propagation, and presumed by the iteration procedure. The high contrast and low magnification images are well corrected by only the iteration procedure. The low contrast and high magnification images, however, have not been corrected yet, although the contrast enhancement slightly improved its correction coverage [1]. In this study, we found that noise level in low contrast image caused undesirable influence on the correction of the non-corrected images. We defined the noise level as noise size, number and height against the target contrast. The simulation was conducted to estimate the optimal noise reduction against the target contrast. The concrete procedure of the noise reduction was median filter. The noise reduction and the contrast enhancement were conducted before the iteration process. The effect was summarized in Table 1. The boundary of low and high magnification is determined by the situation of the non-correction. That is, the former category cannot remove Fresnel fringes on the corrected image, while in the latter category the part of the target images is lost. The improved iteration procedure with the noise reduction and the contrast procedure exceeded the coverage of the correction up to the magnification of 329. The correction of an actual blurred image is shown in Fig.1, and cross-sectional lines show intensity distributions in Fig. 2. The remaining Fresnel fringe on (b) was clearly corrected on (d). As a result, we successfully corrected the low-contrast image in "low magnification category". The correction of the high magnification image with low contrast is in progress by modifying the image acquisition procedure.

Table 1 Image correction table with the iteration procedure.

Process		Magnification						
		Low					High	
		47	99	165	219	329	512	658
①	A	×	×	×	×	×	×	×
②	B→A	○	○	○	○	×	×	×
③	C→A	×	×	×	×	×	×	×
④	C→B→A	○	○	○	○	○	×	×

A: Iteration, B: Contrast Enhancement, C: Noise Reduction
○: Corrected, ×: non-corrected

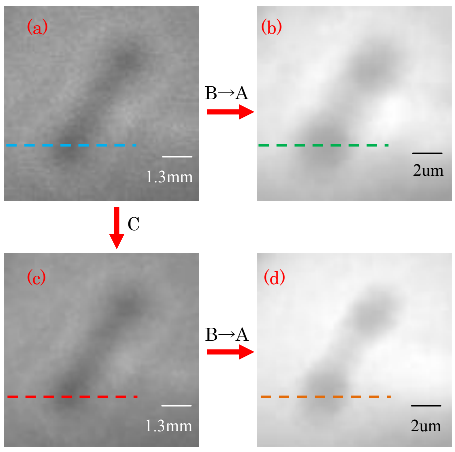

Fig.1 Burr Correction of chromosome image.
(a) Projection image (b) Corrected image B→A
(c) Noise Reduction C (d)Corrected image C→B→A

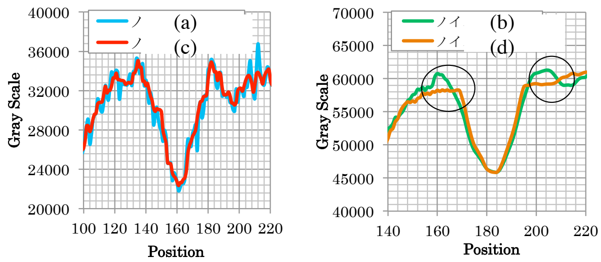

Fig.2 Burr correction on each processes on the images in Fig.1.

References

[1] T. Shiina et al., PF Activity Report 2014 #32 B (2014)
http://pfwww.kek.jp/acr/2014pdf/part_b/pf14b0182.pdf

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