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§42. A Diagnostic of Neutron Fusion by Uniformly Redundant Penumbral Camera

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Neutron imaging is a key technique in laser fusion experiment. However, it is difficult to image neutrons because the neutron has a high transmission. For effective imaging of neutrons, the aperture should be thick enough to block neutrons in order to provide sufficient image contrast. Furthermore the signal-to-noise ratio (S/N) on the detector is low due to the Poisson noise. Uniformly Redundant Penumbral Array method (URPA) can obtain the high S/N image from the detected image[1)]. The reconstruction process contains two steps: one is to use a decoding operator to obtain the real penumbral image and the second step is to use the wiener filter to reconstruct the source like conventional penumbral imaging. The decoded penumbral image by the URPA is shown in Fig. 1. The image contains artifacts by the decoding which is indicated by the arrows. The artifact would distort the reconstructed image. The artifacts are arisen by a error of the position of the penumbral aperture in the experiment. It is impossible to set the position of the penumbral image. Therefore, we have to use another reconstruction method without the decoding operator.

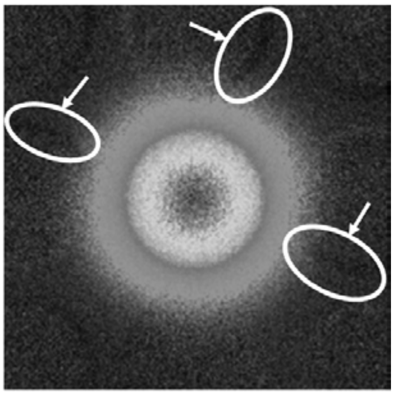

Fig. 1. Decoded penumbral image by the URPA.

Also, it is impossible to obtain a satisfactory isoplanar PSF over a large field of view. Therefore it cannot obtain the perfect isoplanar PSF in neutron imaging. As a result, it cannot directly reconstruct images from detected images. Basic concept of the proposed method is shown in Fig. 2.

In the proposed method, we use only the coding calculation for the reconstruction, that is, we can reconstruct without the decoding operator. The advantage of the proposed method is that we can obtain the reconstructed image even if the satisfactory isoplanar PSF and the decoding operator for the reconstruction do not exist. At first, we set randomly reconstructed object. Next, we calculate the estimated reconstructed image by use of the coding function[1)]. The error between the observed (detected) image and the estimated image is calculated. We update the estimated image to minimize calculated error by using a heuristic method[2)].

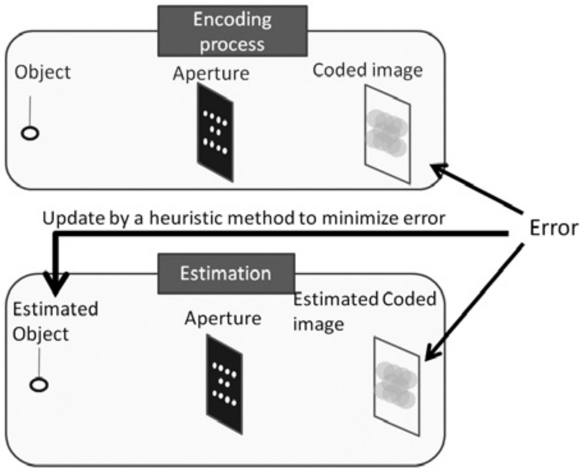

Fig. 2. Basic concept of the proposed method

The results of the computer simulation are shown in Fig. 3. The source image in the computer simulation is shown in Fig. 3(a). The source image is a character "P". The Gaussian noise is added to the decoded image of the source image and its S/N is 0.03 [dB]. In the simulation, we used multi-pinholes instead of the multi-penumbral aperture. The number of the aperture's pinhole is 134, which is added the pinholes of the conventional aperture. The positions of the new pinholes are randomly set. The decoding operator of the generated aperture does not exist so the clear reconstructed image cannot be obtained by use of the decoding operator (Fig. 3(b)). On the other hand, the reconstructed image by the proposed method (Fig. 3(c)) is clearer than the one of the conventional method (Fig. 3 (b)). As future works, we will verify the applicability of the proposed method by using multi-penumbral aperture and we will also apply the method to real-experiment data.

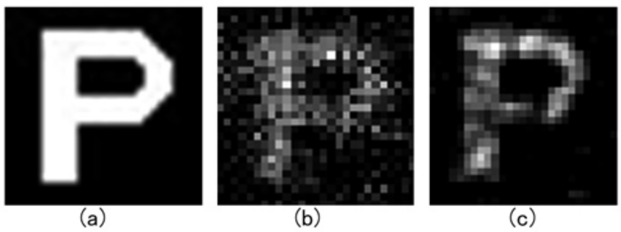

Fig. 3. Computer simulation results. (a): Source image, (b) Reconstructed image by the conventional method, (c) Reconstructed image by the proposed method

1) Chen, Y. et al. Rev. Sci. Instrum., **75** (2004) 4017.
2) Nozaki S. et al. Rev. Sci. Instrum., **74**, (2002) 3198.