§39. A Diagnostic of Laser-imploded Target at Fast Ignition by Uniformly Redundant Penumbral Array Camera

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Penumbral imaging is a technique which uses the fact that spatial information can be recovered from shadow or penumbra that an unknown source casts through a simple large circular aperture [1]. Since such an aperture can be "drilled" through a substrate of almost any thickness, the technique can be easily applied to high penetrating radiation such as neutrons and γ rays. However, in imaging at fast ignition, S/N on the detector is low since small light quantity and γ-ray produced by ultra-intense laser degrades the penumbral image. Therefore the S/N on the detector should be increased to obtain the source image by the penumbral image.

Uniformly Redundant Penumbral Array camera (URPA) can significantly improve the S/N [2]. The basic concept of URPA is shown in Fig. 1(b). The URPA has multipenumbral aperture instead of single penumbral aperture, which are arranged m-sequence. The reconstruction process consists of two steps: one is to use a decoding operator to obtain real single penumbral image and the second step is to reconstruct the source image from the single penumbral image by wiener filter or a heuristic method [3] like conventional penumbral imaging.

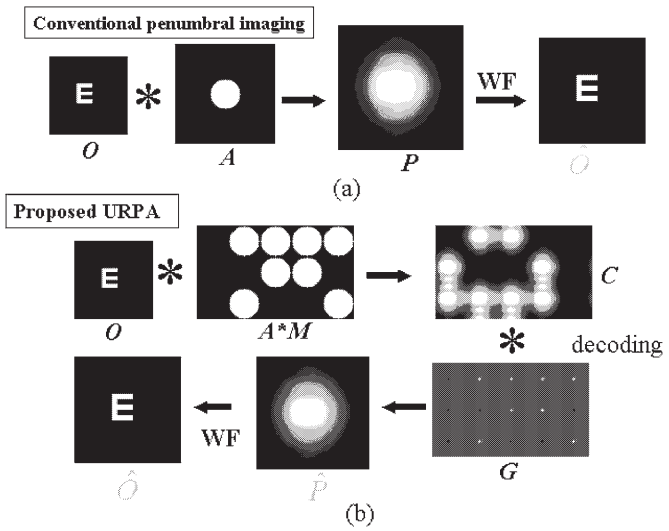

Fig. 1. The basic concept of URPA, (a) conventional penumbral imaging, (b) URPA, the S/N ratio of the decoded penumbral image is improved due to the multi penumbral array aperture.

The penumbral images obtained from an experiment are shown in Fig. 2. Fig. 2(b) and (c) are decoded penumbral images from multipenumbral array aperture (URPA). Each sizes of penumbral array are 5 x 7 and 7 x 9, respectively. It can see that the S/Ns of the penumbral aperture(Fig. 2(b) and (c)) are better than the one of Fig. 2(a) by taking the central signal area of each image. Therefore the proposed URPA can improve the S/N compared with the conventional single penumbral aperture. Furthermore, the improvement of the S/N by the proposed method depends on the number of the penumbral apertures by comparing Fig. 2 (b) and (c).

In order to compare the robustness of the noise by reconstruction method, the reconstructed images and its profiles obtained from Fig. 2(c) are shown in Fig. 3. Though reconstructed images can be obtained by each reconstruction method, the image by the wiener filter (Fig. 3(a)) contains an artifact due to noise. On the other hand, the image by the heuristic method Fig. 3 (b) can be clearly obtained. Therefore, the heuristic method is very powerful tool for the reconstruction in the URPA method.

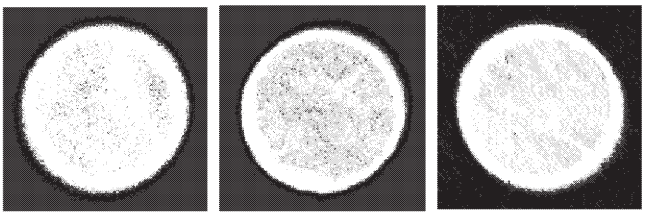

Fig. 2. The obtained penumbral images from an experiments. (a): From single penumbral aperture. (b): From URPA(5 x 7 aperture size). (c): From URPA(7 x 9 aperture size).

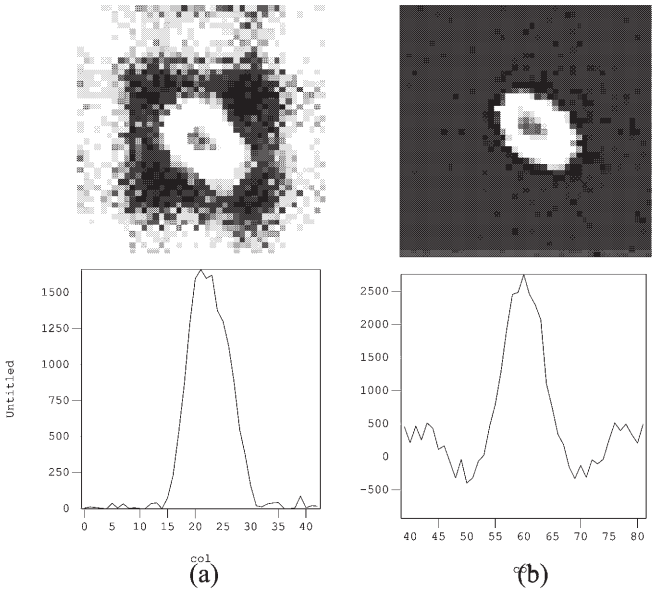

Fig. 3. The reconstructed images and its profiles. (a): Wiener filter. (b):Heuristic method.

1) Nugent K. A., Opt. Commun. **50** (1984) 393.
2) Chen Y.-W., Rev. Sci. Instrum., **75** (2004) 4017.
3) Nozaki S., Rev. Sci. Instrum., **74** (2003) 2240.