§40. X-ray Imaging in Fast Ignition Fusion Experiments
—An Edge Extraction Algorithm Based ICA-Domain Shrinkage for Penumbral Imaging—

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Penumbral imaging is a technique which uses the fact that spatial information can be recovered from the 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 highly penetrating radiation such as neutrons and γ rays. To date, the penumbral imaging technique has been successfully applied to image the high-energy x rays, protons, and neutrons in laser fusion experiments. The limitation of penumbral imaging is that the straightforward deconvolution is very sensitive to noise contained in the penumbral image. The penumbral images are always degraded by Poission noise.

In our previous paper, we proposed a Poisson noise filtering method based on independent component analysis (ICA) for penumbral imaging [1]. Since the spatial information are mainly contained in the penumbral region (edge of the coded image), in this paper we propose an edge extraction algorithm in Poisson noisy images based on independent component analysis (ICA), which is used in the first step (preprocessing) for reconstruction of penumbral images. The goal of ICA is to perform a linear transformation which makes the resulting variables as statistically independent from each other as possible. In image decomposition by ICA, most independent components have super-Gaussian distribution and the corresponding basis functions are similar to localized and oriented human visual response (receptive field). In the proposed ICA-based edge extraction algorithm, the penumbral image is first transformed by the sparse ICA basis functions selected from all of ICA basis functions according to sparseness and then the noise components are removed by a soft thresholding technique filtering, which is known as shrinkage. The flowchart is shown in Fig.1.

Experimental results are shown in Figs.2 and 3. The experimentally obtained penumbral image is shown in Fig.2(a) and its edge image obtained by the proposed ICA-based method is shown in Fig.2(b). The reconstructed images of Figs. 2 (a) and 2(b) are shown in Figs.3(c) and 3(d), respectively. It can be seen that the reconstructed image by the proposed method was much better than that without edge extraction.

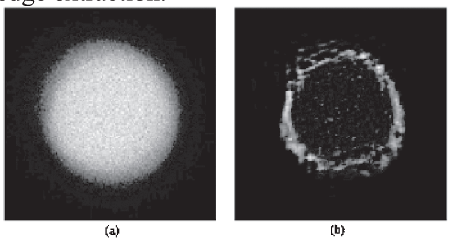

Fig.2 (a) Penumbral image; (b) its edge image.

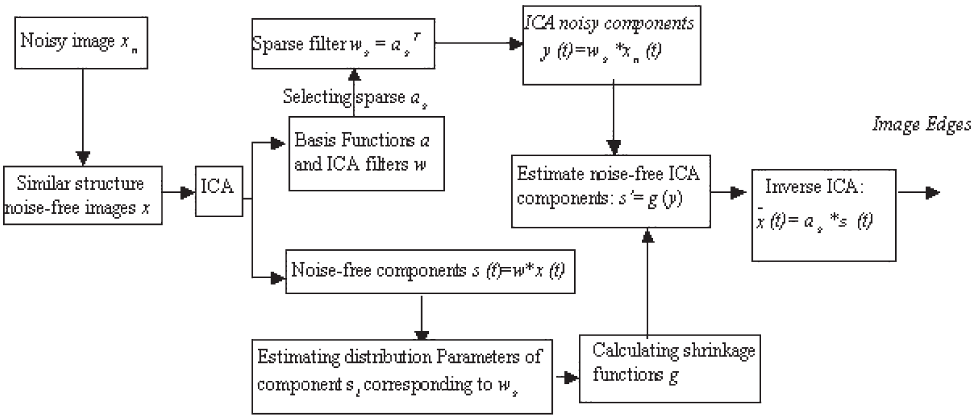

Fig. 1 Flowchart of the proposed method.

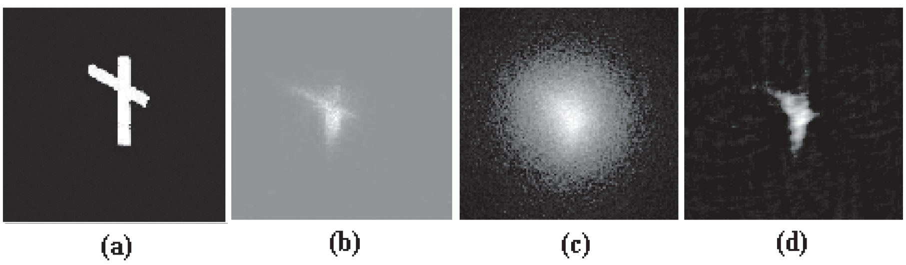

Fig. 3 Desired image (a); pinhole image (b); reconstructed images without edge extraction (c) and with edge extraction (d)

[1] Y.W. Chen, X.Han and S.Nozaki, *Rev. Sci. Instrum.*, Vol.75, pp.3977-3878(2004).