INTRODUCTION

To explore dynamic characteristics of time-series images under deconvolution operation, as coefficients of the test medium’s inclusions, most image reconstruction algorithms yield blurred images because localized information from the object domain is smeared over a range of frequencies and spatial scales in the spatial or frequency domain. The spatial domain is less suited to the concept of deconvolution operation, which is to counteract the information spreading aspect of the optical system. The deconvolution filter, which is to be applied in the spatial or frequency domain, is not usually spatially or temporally stationary. Thus, for a temporal low-pass filter, the spatial domain is usually preferred. Some recent studies have shown that the method works best when applied in time domain directly, rather than in the frequency domain [1].

Spatial Deconvolution Algorithm

The test medium geometry and source-detector configuration used for the filter generation and deconvolution experiments that are reported here are shown in Figure 1. For each experiment, in which the deconvolution filter was used, a comparison between calculated and deconvolved images, for selected time frames within the image sequence, are shown in Figure 5. These results demonstrate the advantages of the method in enabling the numerical recovery of the spatial, temporal and contrast sensitivity of the images to be defined by the shape and spreading parameters of the response in the time domain.

2.2 Dynamic Feature of Inclusions

To consider dynamic characteristics of time-series images under deconvolution operation, as coefficients of the test medium’s inclusions, most image reconstruction algorithms yield blurred images because localized information from the object domain is smeared over a range of frequencies and spatial scales in the spatial or frequency domain. The spatial domain is less suited to the concept of deconvolution operation, which is to counteract the information spreading aspect of the optical system. The deconvolution filter, which is to be applied in the spatial or frequency domain, is not usually spatially or temporally stationary. Thus, for a temporal low-pass filter, the spatial domain is usually preferred. Some recent studies have shown that the method works best when applied in time domain directly, rather than in the frequency domain [1].

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2.3 Detector Noise Model

In most demonstrated cases of this report the white Gaussian noise is added to simulated detector signals to generate temporal low-pass filter curves. The absorption contrast is 2.4.

Figure 1. Panel A, schematic depicting the action of typical DOT image reconstruction algorithm, which yields blurred images because information is smeared over a range of frequencies and spatial scales in the spatial or frequency domain. The absorption contrast is 2.4.

2.4 Quantitative Measures of Spatial and Temporal Accuracy

In this report, we select the spatial and temporal correlations between target medium and reconstructed images as the measurements of spatial and temporal accuracy of reconstructed images, respectively. For reconstruction of reconstructed images, we can obtain the reconstructed distribution $D_N(x,y,t)$.

Where $P(x,y,t)$ is the distribution where the function is defined as follows:

(1) $\mathbf{Y}$ is a random variable that represents the output of an ideal system with input $\mathbf{X}$.

(2) The relation between $\mathbf{Y}$ and $\mathbf{X}$ is given by $\mathbf{Y} = \mathbf{H} \mathbf{X}$, where $\mathbf{H}$ is a linear operator.

(3) The variance of $\mathbf{Y}$ is equal to the variance of $\mathbf{X}$.

The temporal correlation is defined as $\rho_{xy}(\tau)$, where $\tau$ is the time delay.

$\rho_{xy}(\tau) = \frac{\text{Cov}(x(t), y(t+\tau))}{\sigma_x(t)\sigma_y(t+\tau)}$

where $\sigma_x(t)$ and $\sigma_y(t+\tau)$ are the standard deviations of $x(t)$ and $y(t+\tau)$, respectively.

RESULTS

Spatial and quantitative measurements demonstrate the advantages of the spatial deconvolution method when applied to time series images in the test medium. In the test example, in which the deconvolution filter was used, a comparison between calculated and deconvolved images, for selected time frames within the image sequence, are shown in Figure 5. These results demonstrate the advantages of the method in enabling the numerical recovery of the spatial, temporal and contrast sensitivity of the images to be defined by the shape and spreading parameters of the response in the time domain.

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CONCLUSIONS

In this report, we have investigated the effectiveness of the spatial deconvolution algorithm applied to time series images. The qualitative and quantitative results show that (1) For Hadamard or in vivo images (2) The spatial and temporal accuracy of time series images are improved by the deconvolution method. (2) Simple deconvolution filters (e.g. Wiener filters) are easier to create than complex deconvolution filters. (3) For many data presentation methods can significantly improve the spatial accuracy of time series images but decrease the temporal accuracy. (4) Dislement methods (e.g. simple temporal) can enhance the performance of the deconvolution methods.

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REFERENCES