Transactions of the Korean Nuclear Society Spring Meeting
Chuncheon, Korea, May 25-26 2006

Scatter Point Spread Functions for Scatter Correction in Dual Energy Radiography

Seong Kyu Ahn [1], Eui-Jin Lee [1], and Gyuseong Cho [2]
[1] *Nuclear Training Center, Korea Atomic Energy Research Institute, P.O.Box 105 Yuseong Daejon 305-353, Korea*
[2] *Department of Nuclear and Quantum Engineering, Korea Advanced Institute of Science and Technology, 373-1 Guseong Yuseong Daejon 305-701, Korea*

1. Introduction

Dual energy x-ray radiography can be used to separate soft and dense-material images for medical and industrial applications [1]. It can be performed successfully with a line-scanning system because of its scatter-free nature. With area detectors, however, scattered radiation also contributes to the signal. This undesired behavior of scattered x-ray photons in radiography causes serious degradation of contrast in observed images, and poor separation of soft- and dense-material images. The scatter correction method in dual-energy radiography called the thickness estimation-based scatter correction method (TB correction) was previously suggested [2], which is based on iterative thickness estimation using unique scatter point spread functions. For this correction method, information of scatter point spread functions (SPSFs) is needed. The detailed measurement methods and results for the SPSFs are discussed in this study.

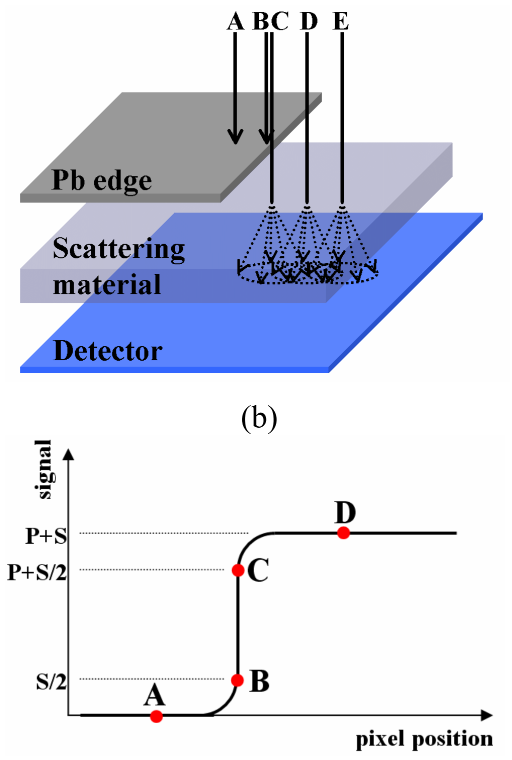

Figure 1. The basic acquisition geometry (a) and the resulting signal profile (b).

2. Methods and Results

Scatter point spread functions are depended on a system and application [3]. Every imaging system has different x-ray spectra and detector. Therefore, proper SPSFs need to be measured for the proper TB correction. In a simulation, it is not hard to generate scatter point spread functions and the scatter-to-primary ratio using a pencil-beam, a point detector or other techniques. In a real situation, however, it is very difficult to measure of them. First of all, the edge spread function (ESF) is measured, and then mathematical process is following to generate the point spread function (PSF).

2.1 Basic Methods for Point Spread Functions

It is well known that the first derivative of the edge spread function is the line spread function (LSF) as in the below equation,

$$lsf(x) = \frac{d}{dx}[esf(x)] \qquad (1)$$

The Fourier form of LSF is exactly same with a profile of Fourier formed PSF along the corresponding frequency axis.

$$PSF(u,0) = \int_{-\infty}^{\infty}\int_{-\infty}^{\infty} e^{-iux}\, psf(x,y)\,dy\,dx = LSF(u) \qquad (2)$$

With assumption of rotational symmetry of the image, the full scale of Fourier transformed PSF can be calculated from the profile of the Fourier formed PSF, and the inverse transformation gives the PSF.

2.2 Measurement of Scatter Edge Spread Functions

In this study, Cooper's technique [4] was used to measure the scatter edge spread function. Figure 1 shows the basic acquisition geometry (a) and the resulting signal profile (b). X-rays incident on a radiopaque edge (e.g. Pb plate) placed on a scattering phantom, and the edge should be oriented parallel to the anode-cathode axis and bisects the x-ray field. A digital detector resides beneath the scattering medium. In the profile of ESF in Figure 1(b), the amount of scattered signal (S) and primary-only (i.e. scatter-free, P) signal can be estimated by following equations.

$$S = 2 \times [ESF\ (D) - ESF\ (C)] \qquad (3)$$

$$P = ESF\ (D) - S \qquad (4)$$

In a real experiment, because the primary-only ESF is not a perfect step function, more complicate scaling and subtraction should be concerned.

2.3 Measured Scatter Point Spread Functions

Measured edge spread functions with and without scatter media are shown in Figure 2. The primary edge spread function (PESF) is a profile of tungsten edge without any scatter media, and the primary and scatter edge spread function (PSESF) is a profile with scatter media. The bottom graph in Figure 2 is scaled edge spread function to calculate the amount of scattered x-ray by scatter media. The differential edge spread function (DESF in Figure 3) have the magnitude of the scatter amount, S, in equation 3.

$$DESF = Scaled\ PESF - Scaled\ PSESF \qquad (5)$$

The scatter edge spread function (SESF) is generated by subtraction of normalized primary ESF (*NPESF*) with the scatter amount from the original ESF (*PSESF*).

$$SESF = PSESF - NPESF \qquad (6)$$

The final scatter point spread function (SPSF) is shown in Figure 3. The magnitude of scattered x-ray is equal to the height of DESF (top). Normalized scatter point spread function by experiment is generated and compared with simulated a SPSF by MCNP code (bottom). Measured SPSF is boarder than simulated SPSF because of more scatter by a detector and bigger distance from the scatter media to the detector in the experiment than in simulation.

3. Conclusion

The TB correction method uses information from a dual-energy algorithm to correct the images. The measurement of scatter point spread functions were proposed and verified by comparing with MCNP simulated results. This way to measure the SPSFs can give the great possibility for various other applications to the TB scatter correction method in dual-energy radiography.

REFERENCES

[1] R. M. Harrison, Digital radiography-a review of detector design, Nuclear Instruments & Methods in Physics Research Section a-Accelerators Spectrometers Detectors and Associated Equipment, V.310 No.1-2, pp.24-34, 1991.

[2] S. K. Ahn, G. Cho, and H. Jeon, A Scatter Correction Using Thickness Iteration in Dual-Energy Radiography, IEEE Transaction on Nuclear Science, V.53, No.1, pp.133-138, 2006.

[3] H. Du and K. J. Voss, Effects of point-spread function on calibration and radiometric accuracy of CCD camera. Applied Optics, V.43, No.3, pp.665-670, 2004.

[4] V. N. Cooper, et al., An edge spread technique for measurement of the scatter-to-primary ratio in mammography, Medical Physics, V.27, No.5, pp.845-853, 2000.

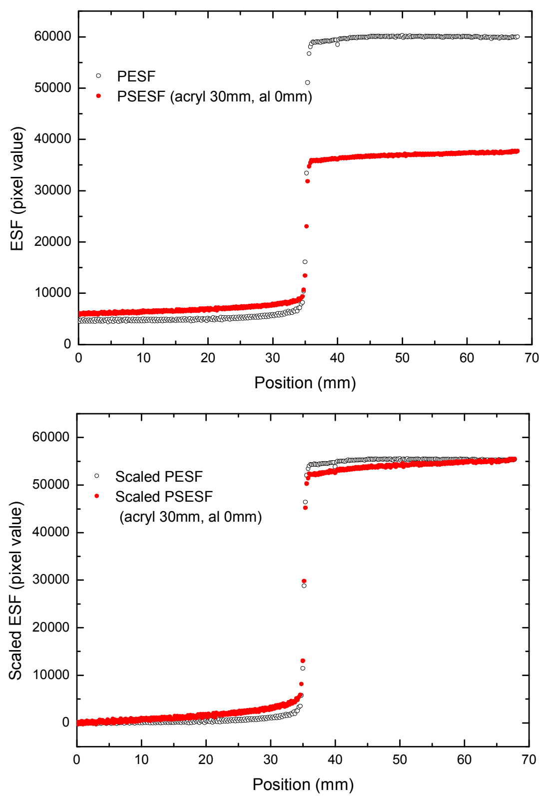

Figure 2. Edge spread function with and without scatter media. See the text for detailed explanation. Scatter media is 30 mm of acryl.

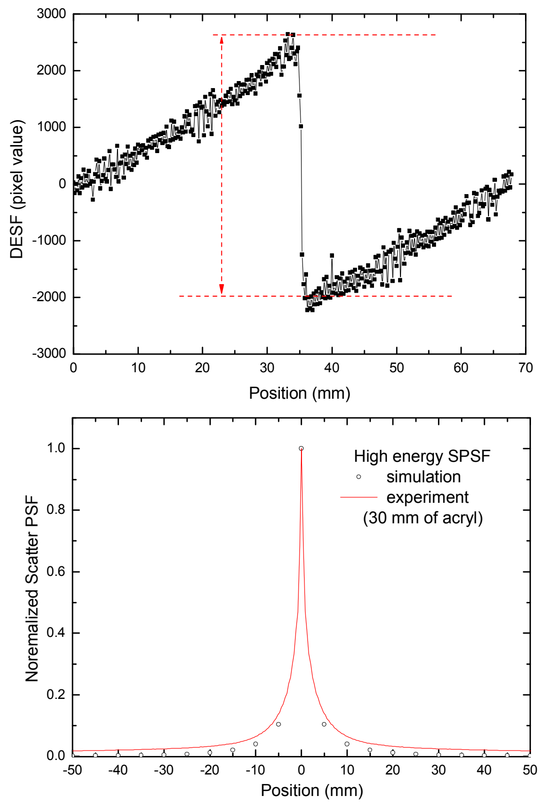

Figure 3. Differential edge spread function (DESF) and scatter point spread function (SPSF). See the text for detailed explanation.