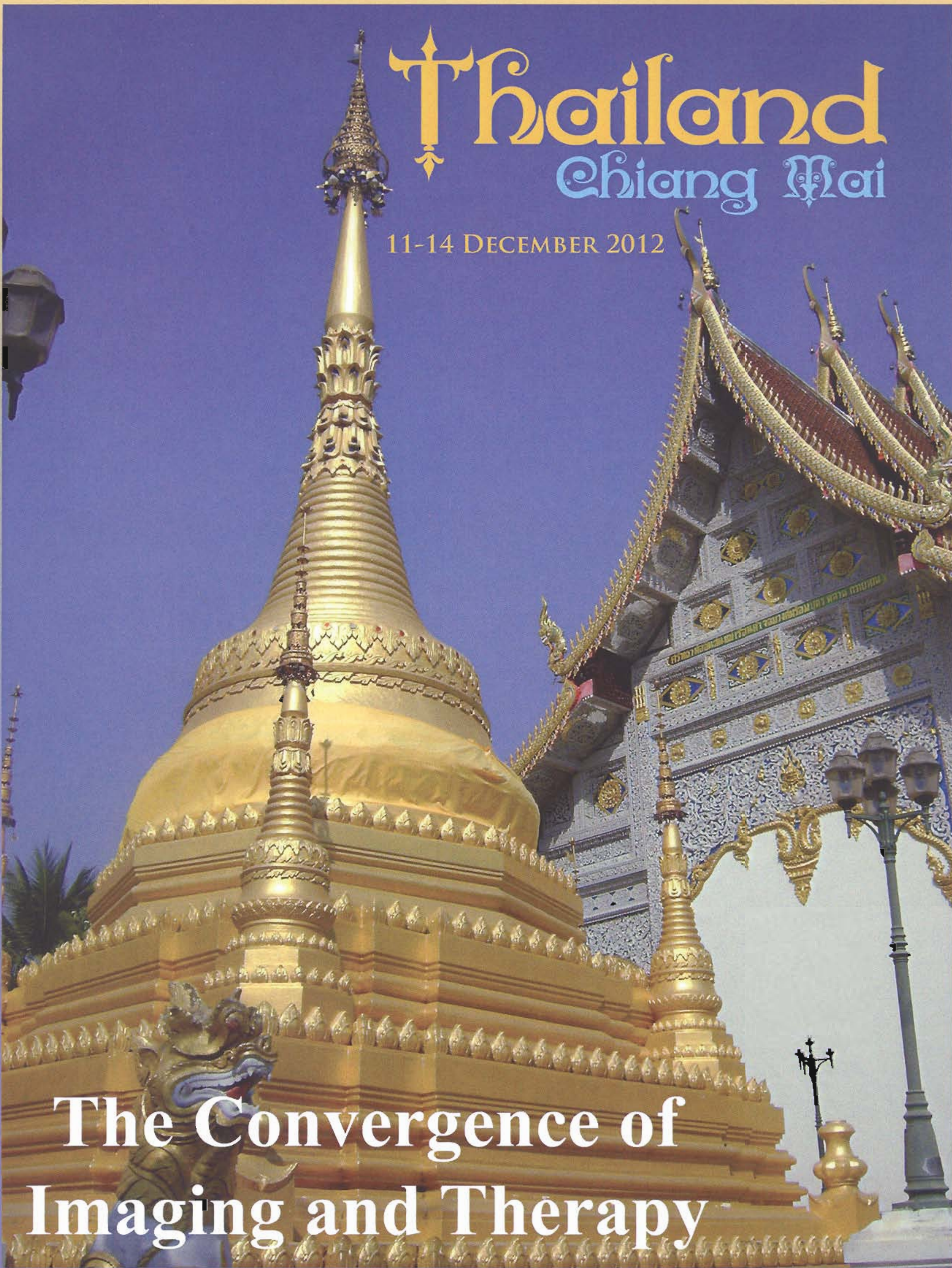
Thailand
Chiang Mai

11-14 December 2012



The Convergence of Imaging and Therapy

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12th Asia-Oceania Congress of Medical Physics

(12th AOCMP)

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Khum Phu Come Hotel

Chiang Mai,

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12^{th} Asia-Oceania Congress of Medical Physics,
and
10^{th} South East Asian Congress of Medical Physics

Organized by

Thai Medical Physicist Society
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Application of Mathematics for Noise Reduction and Edge Detection in Medical X-ray Image

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Abstract— **X-ray imaging plays a major role in medical diagnosis. It is a noninvasive medical test that helps physicians diagnose. Instead of using x-ray film, digital radiography is now widely regarded as the standard technology. It has a wide dynamic range, which makes it more available for overexposure and underexposure. A digital x-ray image can be stored for a long time without degradation and it can be processed further. However, there is always noise which reduces the quality of the observed images. If we can reduce the noise, the radiologist will diagnose the x-ray image accurately. Edge detection is a fundamental tool used in most image processing applications to obtain information from the frames as a precursor step to feature extraction and object segmentation. It is used for detection and localization of pathological deformations. The objective of this paper is to apply mathematics and algorithms for noise reduction and edge detection. Eperiments have been done, the x-ray image has been investigated to specify the kind of noise, next algorithms have been adapted for noise reduction, then methods for edge detection have been studied, after that they have been analyzed so as to choose the best technique, finally x-ray images have been processed for edge detection. The results have shown that our algorithm is capable of reducing severe noise with linear noise reduction. Also Canny's operator for edge detection provides optimal result for x-ray image. The filter of linear noise reduction has been chosen to reduce the noise in computed radiography. The operators have used edge detectors like Sobel, Canny, Prewitt, Roberts, LoG and Zero-crossing. The results have been compared with a variety of other methods. It has been seen that Canny's operator has best edge detection for x-ray images. This paper has investigated to find the type of noise in computed radiography, and algorithms have been applied for noise reduction and edge detection. This research is a technique to analyze medical x-ray images which is a basis for development in the future.**

Keywords— **Noise reduction, edge detection, x-ray image**

I. INTRODUCTION

Computed radiography (CR) uses a photostimulable storage phosphor that stores the latent image with subsequent processing using a stimulating laser beam and can be easily adapted to a cassette based system analogous to that used in screen-film radiography [1]. The advantages of CR are wide dynamic range, post processing capability, portability and digital storage.

Image noise, sometimes referred to as image mottle, gives an image a textured or grainy appearance. The source and amount of image noise depend on the imaging method [2]. The term quantum is defined as "something that may be counted or measured," and in medical imaging quanta is a generic term for signals that come in individual, discrete packets. When discussing the number of x-ray quanta, it is common nomenclature to use the symbol N as the mean number of photons per unit area. For a digital x-ray detector system with square pixels, if the average number of x-rays recorded in each pixel is N, then the noise will be

$$\sigma = \sqrt{N} \tag{1}$$

where σ is called the standard deviation or the noise [3].

Edge detection is a very important area in the field of Computer Vision. Edges define the boundaries between regions in an image, which helps with segmentation and object recognition. They can show where shadows fall in an image or any other distinct change in the intensity of an image. Edge detection is a fundamental of low-level image processing and good edges are necessary for higher level processing [4]. The most commonly used methods for edge detection include Sobel, Canny, Prewitt, Roberts, LoG and Zero-crossing.

In this study we investigated the noise in CR, applied an algorithm for noise reduction and compared edge detection methods for an x-ray image.

II. MATERIALS AND METHODS

A. Materials

Toshiba KXO-50R, FCR Capsula XLII and imaging plate 20.1 cm x 25.2 cm were x-ray equipment in this study. The phantom utilized in this study was constructed as shown in Fig. 1. They were composed of 2 cm thick acrylic sheets of sizes 12 cm x 12 cm, 10 cm x 10 cm, 8 cm x 8 cm and 6 cm x 6 cm. Lena image (512 x 512 pixels) shown in Fig. 2, and the chest x-ray image (Fig. 5) were sample pictures for studying.

B. Methods

The phantom was exposed for characterizing the relation of charges and noise. By the experiment, mAs varied from

2, 4, 6, 8 to 10, where the peak kilovoltage was fixed at 55 kVp. The values of noise observed for each mAs were shown in Table 1. In order to classify the type of noise in CR, a phantom was exposed with 5 mAs and 55 kVp. To obtain the raw image data, the vendor's software was set to process the x-ray image without noise reduction. The data of the x-ray image was subtracted from the data of the real image. The histogram of the subtracted data was investigated by comparing to the histograms of known types of noise. The algorithm for an x-ray noise reduction was chosen from one which provides the highest correlation and the lowest standard deviation. The noise reduction model is

$$\hat{f}_i(x,y) = g(x,y) * \text{Algorithm-}i \ , \qquad (2)$$

where $\hat{f}_i(x,y)$ is a reconstructed image by algorithm-*i*, $g(x,y)$ is an image with noise.

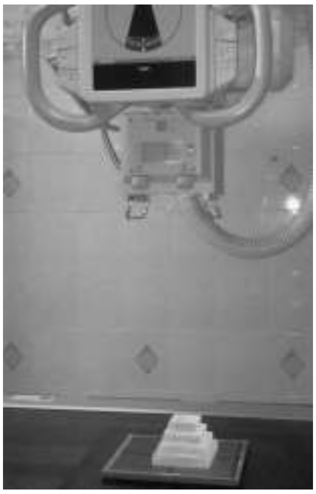

Fig. 1 Phantom

There were several operators used for the edge detection, i.e. Sobel, Canny, Prewitt, Roberts, LoG and Zero-crossing. These operators were applied to the Lena image (Fig. 2). They were surveyed for finding the optimal edge detection method for x-ray image (Fig. 4).

Fig. 2 Lena image

III. RESULTS

The results of noise for each mAs are shown in Table 1.

Table 1 Noise for each mAs

mAs	σ
2	1.61
4	1.52
6	1.39
8	1.17
10	0.98

The histograms of CR image and noise in CR are shown in Fig. 3

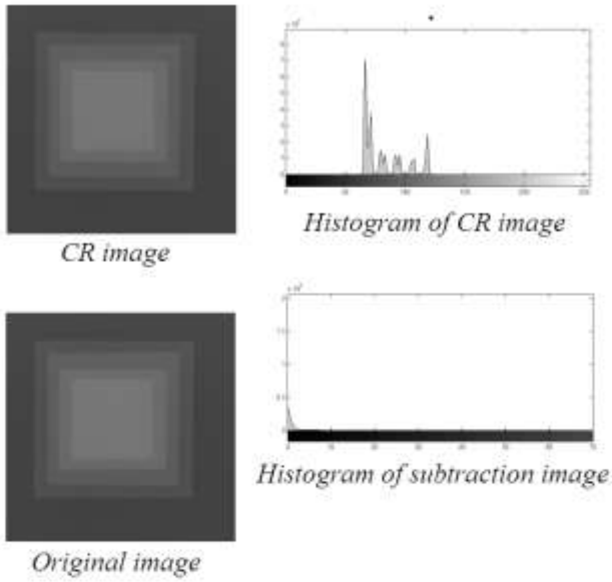

Fig. 3 Histograms of CR image and noise in CR

The results of noise reduction are shown in Table 2.

Table 2 Noise and the correlations of original image and the reconstructed images for 6 algorithms.

Algorithm*	σ	**Correlation (Original image & result image)**
Algorithm-1	18.0620	0.9980
Algorithm-2	18.0635	0.9980
Algorithm-3	18.0651	0.9980
Algorithm-4	18.0415	0.9978
Algorithm-5	18.1003	0.9979
Algorithm-6	18.0984	0.9978

* Algorithm-1 uses average Gaussian average filters.
Algorithm-2 uses average Gaussian disk filters.
Algorithm-3 uses disk Gaussian disk filters.
Algorithm-4 uses average disk disk filters.
Algorithm-5 uses Gaussian disk Gaussian filters.
Algorithm-6 uses average Gaussian Gaussian filters.

The pictures processed for the edge detection are shown in Fig. 4.

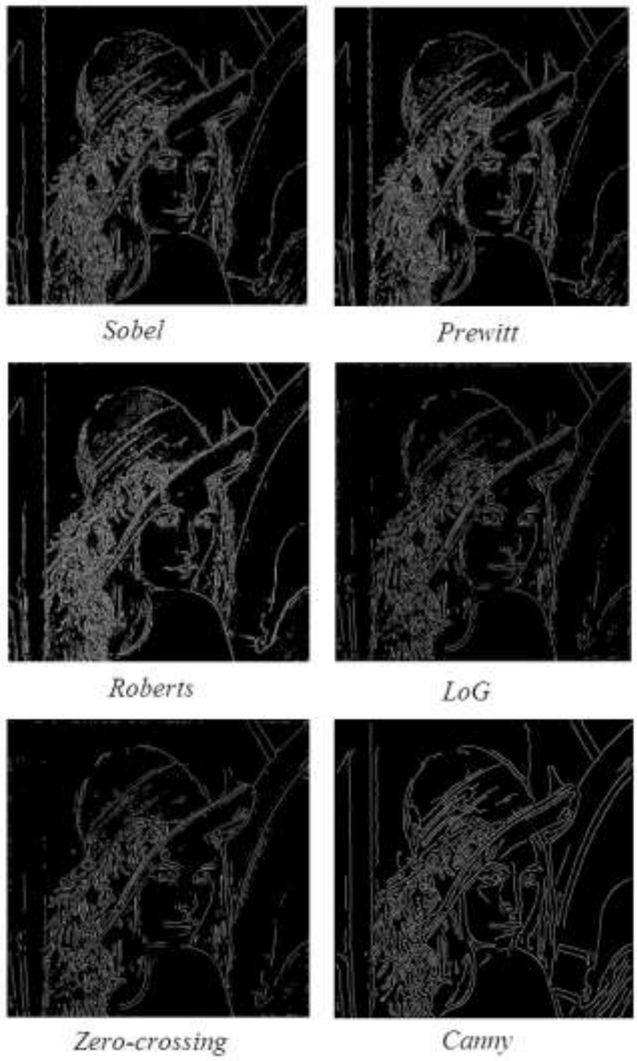

Fig. 4 Edge detection

Finally, algorithm-1 for noise reduction and Canny's operator for edge detection were selected to apply to the chest x-ray image, as shown in Fig. 5.

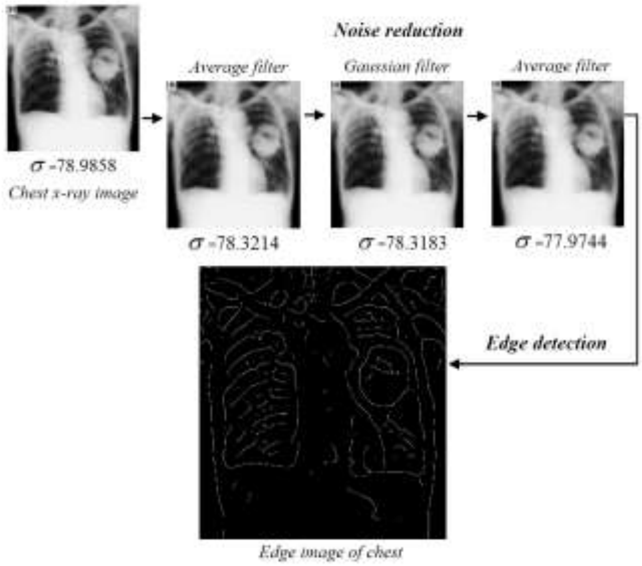

Fig. 5 Application of noise reduction and edge detection to the chest x-ray image

IV. Discussion

It was found that when we increased the mAs, the standard deviation or noise decreased linearly, as shown in Fig. 6. The histograms of CR image and subtraction image relate with histogram of Poisson noise, as shown in Fig. 7. The application for noise reduction applied the linear noise reduction, the algorithm-1 was the optimal method for this study, as shown in Fig. 8. Also the Canny's operator was selected to be the method for edge detection.

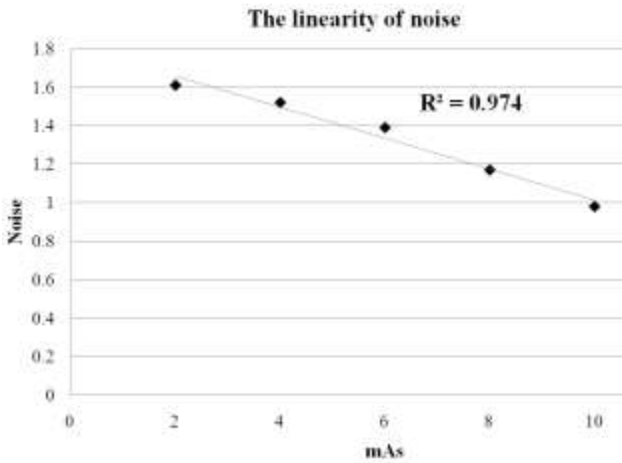

Fig. 6 The linearity of noise

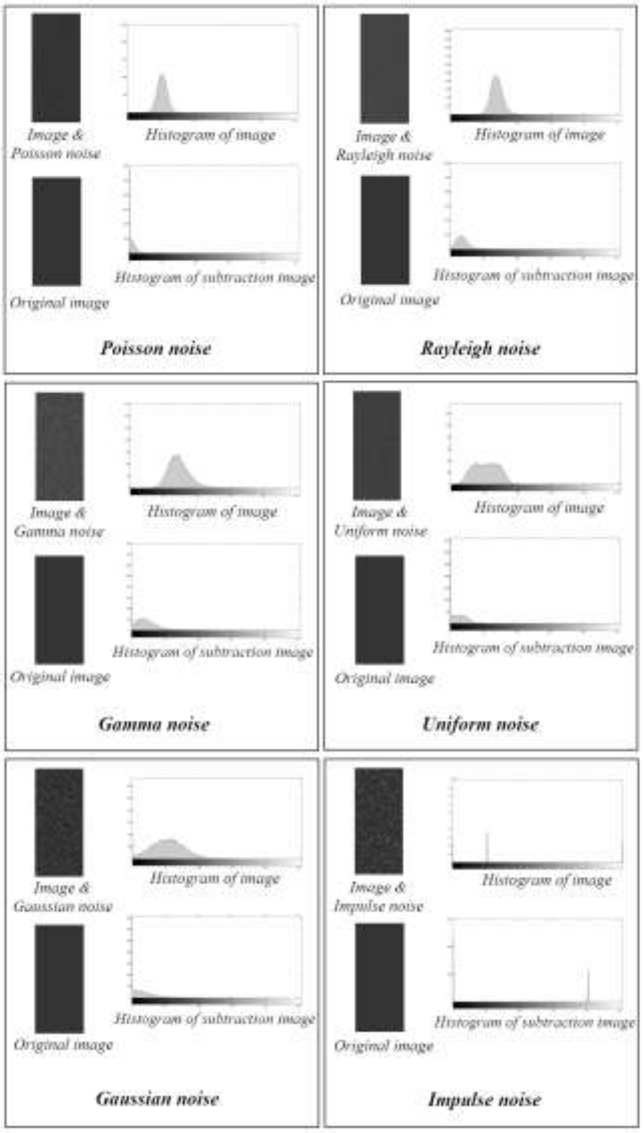

Fig. 7 Histogram of known types of noise

V. Conclusions

This study investigated to find the type of noise in CR that we related histogram from CR image with histogram of noise. The algorithms applied for noise reduction that we used were the linear noise reduction three times. The edge detection operators, Sobel, Canny, Prewitt, Roberts, LoG and Zero-crossing were applied for x-ray image that Canny's operator optimized for this study. This research is technique to analyze medical x-ray image that may be used as a basis for development in the future.

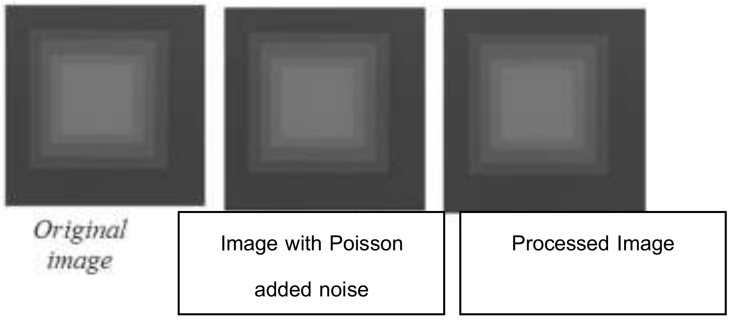

Fig. 8 Resulting image of algorithm-1

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