Improving X-Ray Image Contrast with a Lower Radiation Dose in an Anti-Scatter Grid

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Abstract– ***Current medical technologies in the imaging field offer various opportunities for optimization. The main focus of this research will be to propose an anti-scatter grid with a different interspace material, urethane foam, and lower grid frequency than currently available commercial ones. Design parameters will set the grid ratio at 10:1. Throughout the future work, optimization will play a key role, since the manufacturing aspect of grids requires the implementation of high-precision equipment.***

Keywords—radiology, imaging, computed tomography, manufacturing, x-rays.

I. Introduction

More than 100 years ago, Dr. Gustave Bucky invented the radiographic anti-scatter grid, and until present time it remains the best method for scatter removal from an x-ray field. [1] Fig. 1 depicts a radiographic system consisting of an x-ray source opposed by an image receptor with a reclining patient in between.

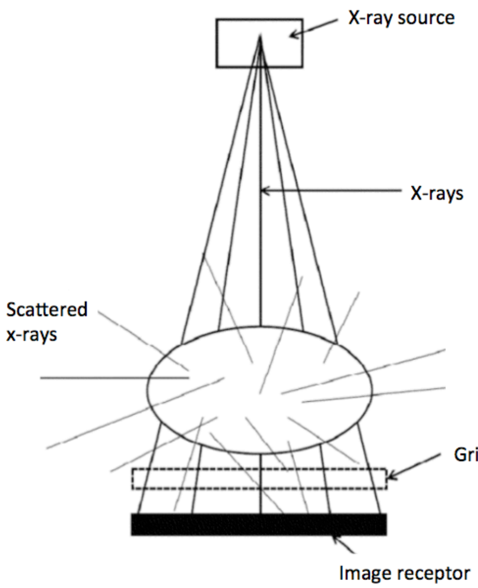

Fig. 1 Simple radiographic system configuration.

The dotted rectangle in Fig. 1 refers to the typical position of the anti-scatter grid. The grid is made with lead lamellae focused to the x-ray source allowing primary x-ray radiation to pass through to the image receptor while absorbing scattered x-rays. The effectiveness of the grid is commonly measured with the contrast improvement factor (K) because scatter degrades the image by reducing image contrast. The grid has important effects on patient radiation dose because primary radiation absorbed by the grid must be compensated by a higher radiation dose.

Fig. 2 shows four images and the effect on the contrast of implementing a grid can be appreciated.

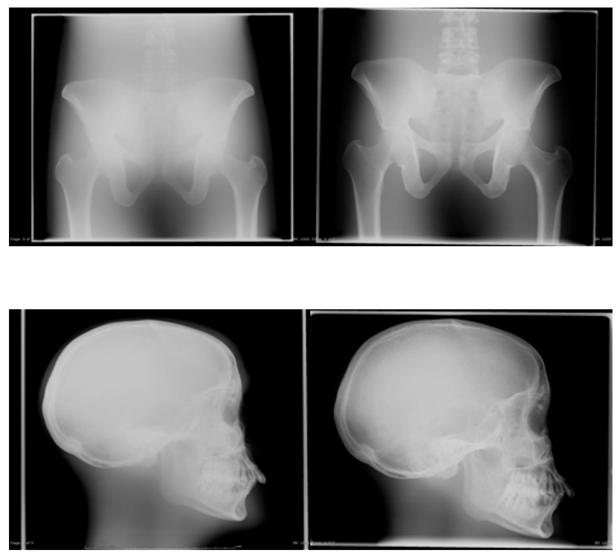

Fig. 2 Radiographs of two different regions of the body without and with anti-scatter grids [2]

The two radiographs on the left side of Fig. 2 were acquired without a grid; the two on the right side used a grid, and an improvement in contrast is noticeable, particularly with the hip region x-ray. This depicts the importance of properly using an anti-scatter grid in imaging. The main focus of this research is in *reducing* patient dose by *increasing* primary transmission while also improving contrast by *reducing* scatter transmission.

II. Initial Work

A. Design Parameters

Preliminary work had employed simulations based on analytical methods. The characteristics of the proposed grid are listed in Table I, as well as the properties of conventional aluminum interspace grids. The design approach is to remove scatter more effectively with a relatively thick grid with more effective lead lamellae while improving dose performance with an interspace material that is much more transparent to x-rays than the usual aluminum.

TABLE I
COMPARISON OF COMMERCIAL GRIDS TO PROPOSED GRID

Characteristics	Commercial Grid [3]	Proposed Grid
Frequency	40 and 80 lines/cm	~ 8.9 lines/cm
Height	0.2 and 0.1 cm	1 cm
Focal distance	100 cm	100 cm
Grid ratio	10:1	10:1
Interspace material	Aluminum	Urethane foam
Density of interspace material	2.7 g/cm^3	0.8 g/cm^3 [4]

The main difference of the proposed project with respect to commercial grids is that the overall height is much larger than the current standards, and there are less lines/cm.

B. *Attenuation - Simulation*

Fig. 3 shows similarities of transmitted flux (total number of photons) from primary x-rays at 100 kVp obtained from a simulation through 1 cm of urethane foam versus 0.2 cm and 0.1 cm of aluminum.

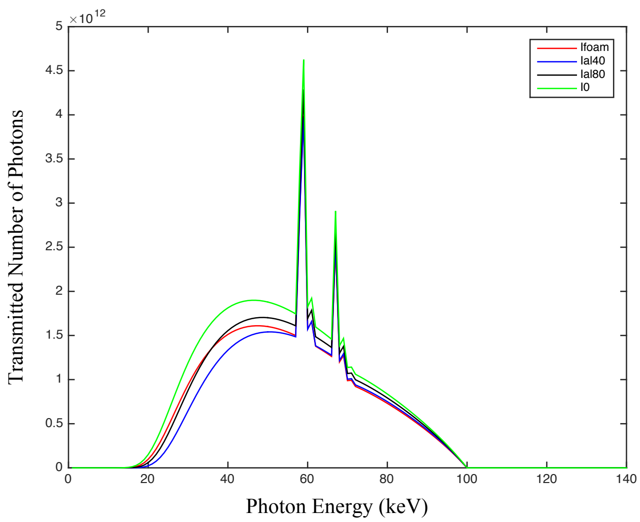

Fig. 3 Number of photons after attenuation through interspaces materials (aluminum and urethane foam) at 100 kVp.

Using equation (1) the number of photons was calculated for the specified thicknesses of aluminum and urethane foam.

$$I = I_0 e^{(-\mu l)}. \quad (1)$$

The spectrum of 100 kVp (I_0) shown in Fig. 3 serves as a reference for the maximum transmitted flux from primary x-rays, these values were obtained with nothing in the beam (no interspace material from a grid).

C. *X-Ray Scatter - Simulation*

Fig. 4 shows the behavior of scattered flux depending on an array of angles throughout the length of a proposed half grid. The primary x-rays (I_0) for this simulation used 30 cm of water attenuation, before computing the Compton scattering.

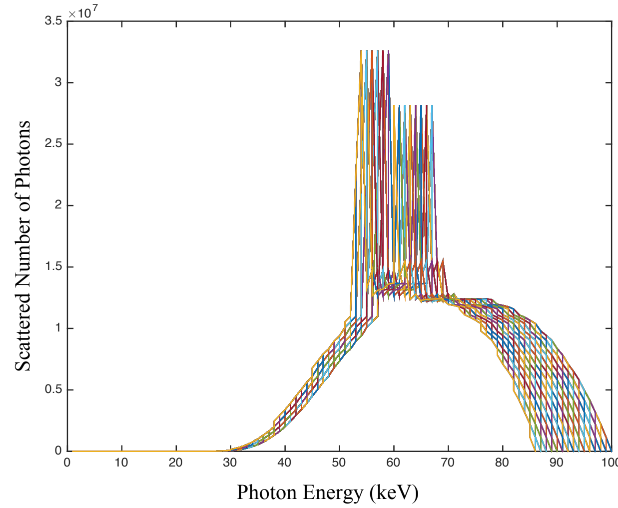

Fig. 4 Energy from Compton scattering at 100 kVp before grid.

Ultimately the total amount of scatter would be doubled since the simulation accounts for half a grid, mirroring the quantities on both sides of the focal axis of the lead lamellae to the x-ray source. The trend observed in Fig. 4 shifts the scatter spectra to the left showing that the further away a scatter source is from the image receptor (wider angle), the smaller the energy that will enter the grid for attenuation.

III. FUTURE WORK

1) Simulations: continue to perform computations using the proposed grid and current commercial grids characteristics to “visualize” potential optimization configurations.

2) Experiments: collect data for the proposed material under an x-ray beam; this will help determine actual attenuation of available manufacturing materials. It will function as a baseline of what is commercially available, and whether a different interspace material can be considered.

3) Design: work towards developing an overall concept of the project with proposed constraints, and create a modular solution for approaching the manufacturing aspect. This will also encompass a proposed bucky that will have to be developed in order to substitute a current set-up.

ACKNOWLEDGMENT

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[4] Polyurethane Foam Association web page. “Density Standards and Guidelines.” www.pfa.org