The CARESTREAM Tube and Grid Alignment System provides better image quality and consistent techniques for portable diagnostic radiography

Anti-Scatter Grids Improve Image Quality

Scattered radiation is a major contributor to reduced image quality in diagnostic radiography. Anti-scatter grids, when properly aligned, provide an effective means for reducing scatter [1-6]. The preferential transmission of primary versus scattered X-rays improves the contrast-to-noise ratio (CNR). Figure 1 shows a pair of portable chest images captured of an ICU patient with and without grids and under the same exposure conditions. Comparing the two images, the contrast improvement with grids is significant.

Figure 1 -- Comparison of portable chest images captured of an ICU patient without (left) and with (right) anti-scatter grid

Grid Benefits Can be Realized with Less Exposure Increments in Digital Radiography

The Bucky factor is the reciprocal of the total X-ray penetration through an anti-scatter grid. The analog screen-film system has a fixed sensitometry response. When a grid is used, a Bucky factor technique increment was necessary to ensure sufficient exposure to produce a film image with proper density and contrast for diagnosis.

The benefits of anti-scatter grids can be realized in digital radiography (DR) with less exposure technique increments than would be indicated by traditional Bucky factors [7]. This is because DR does not have a fixed sensitometey response; the global contrast and brightness of a DR image can be arbitrarily modified by digital image processing. DR systems are fundamentally noise limited – within a broad range of exposure levels to the patient, the image quality is determined by the anatomy CNR in the captured image. Anti-scatter grids can improve the image CNR at a minor expense of reduced primary X-ray transmission. This suggests some exposure technique increase may be required to compensate for primary X-ray attenuation, but usually at a lower level than the Bucky factor.

Challenges in Using Grids for Portable Radiography

Grid usage in portable radiography is often sporadic and inconsistent. This causes greater variability in image quality, and a greater number of radiographs of poorer quality than those captured in the radiology department being delivered for interpretation.

From the perspective of the radiographic technologist, using grids for portable exams involves a variety of time-consuming workflow implications. These include attaching and detaching the add-on grids to the X-ray cassettes; the stringent requirements to properly position and align the X-ray source relative to the cassette behind the patient to avoid grid cutoff; the increased probability that repeated exposures will be required due to grid-cutoff artifact; and more.

In addition, there is the misperception that grids are not required in digital radiography because increasing the exposure can overcome the scatter-noise level, and that image processing adjustments, such as window and level manipulations, can sufficiently compensate for the quality losses that are introduced by scattered radiation. With all of these considerations in mind, there would seem to be little motivation for the technologists to use grids in portable digital radiography.

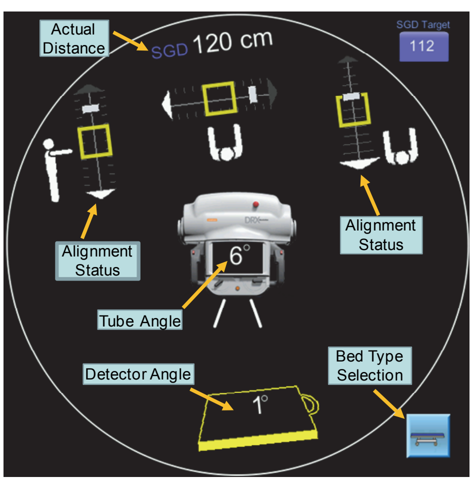

Figure 3 – The tube-head display on the DRX-Revolution System reports real-time X-ray source and grid/detector position information for proper alignment.

DRX-Revolution Tube and Grid Alignment System

The CARESTREAM Tube and Grid Alignment System (TGA) for the CARESTREAM DRX-Revolution Mobile X-ray System provides guidance to the radiographic technologist for proper alignment of the X-ray source relative to the grid/detector. This optional feature integrates seamlessly with the DRX-Revolution System – no additional operational steps are required in the normal workflow (Figure 2).

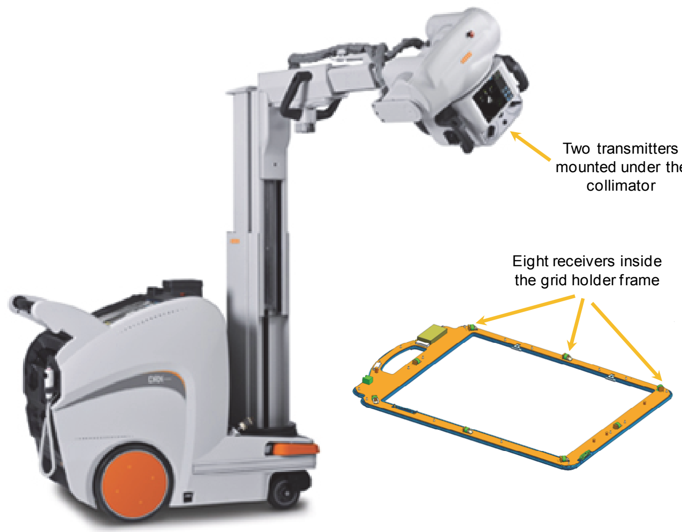

Figure 2 – The DRX-Revolution and schematics of the optional Tube and Alignment System. The grid-alignment transmitters are built inside the tube-head assembly, and the receivers are in the grid holder.

Carestream's TGA helps the radiographic technologist to achieve better image quality and consistent imaging technique for portable exams. It automatically detects the X-ray source position relative to the grid holder/detector, and then reports the amount of X-ray source displacements from the proper alignment (Figure 3). The displacements are presented in real time on the tube-head display in separate up/down, left/right and in/out directions. The alignment status turns green when the TGA decides that the X-ray source is within the optimal grid-operation range, specific to the target source-to-grid distance (SGD).

Alignment Technology Overview

The TGA uses multiple electromagnetic fields for position triangulation. Two transmitters are mounted under the X-ray collimator to generate the electromagnetic fields, and a total of eight receivers are installed inside the grid holder around the grid/detector to detect the fields from the transmitters (Figure 2). The transmitters use magnetic coils to synthesize magnetic fields that are functionally the same as those of spinning, permanent bar magnets (Figure 4). The receivers sense the spinning magnetic-field intensity and phase, and then each generates a unique sine-wave signal (Figure 5).

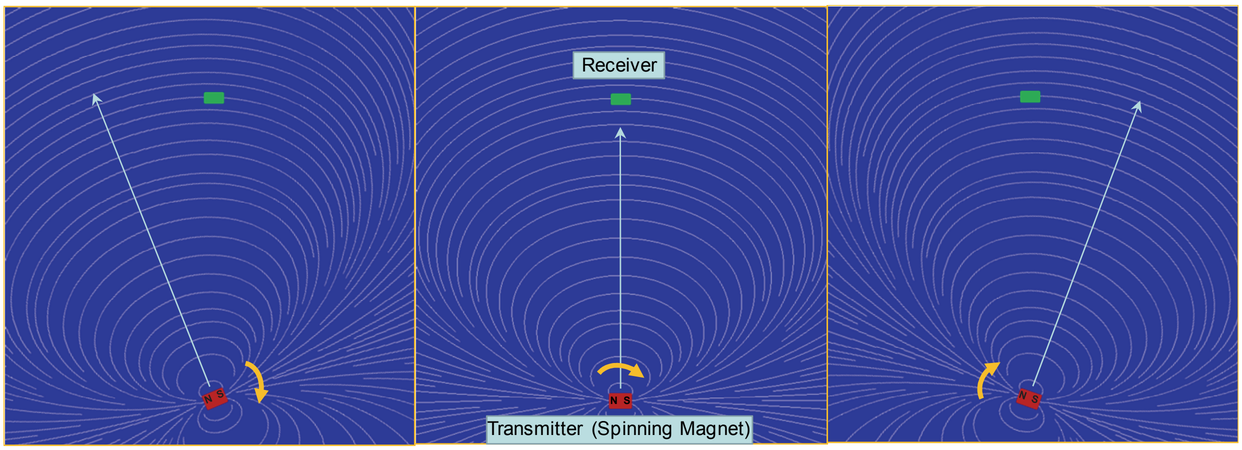

Figure 4 – The Tube and Grid Alignment System works by detecting the intensity and phase of synthesized spinning magnetic fields. These diagrams show three examples of different relative positions between a transmitter and a receiver.

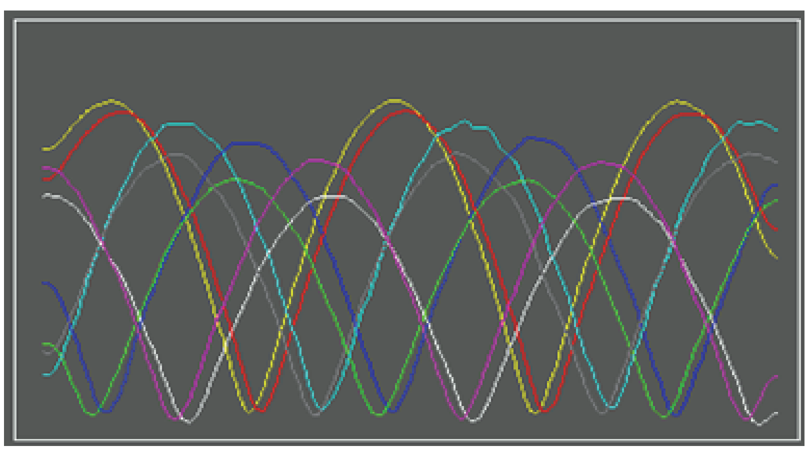

Figure 5 – A snapshot of the detected magnetic-field signals from eight receivers

Sophisticated mathematical models are built inside the software to decode the receiver sine-wave information. The magnitude and phase of the sine wave from each receiver are extracted from the electronic signals, and then compared with their expected theoretical values, which are calculated based on an initial assumption of the geometry between the X-ray source and the grid holder/detector. A total error is summed from the comparison differences for all the receivers. A non-zero total error value indicates that the initial geometry assumption is incorrect, to which fine adjustments are made and the calculation process is reiterated. The X-ray source position is best estimated when the total error is minimized. Finally, the estimated position value is compared to the optimal grid-operation range, and the X-ray source displacements from the proper alignment are presented on the tube-head display.

The grid-alignment transmitters use amplitude-modulated radio-frequency (RF) signals for extended operation range and improved signal-to-noise ratio. Eddy current can be induced by the transmitter RF signals in the metallic material that is in close proximity to the receivers. The Eddy current introduces secondary electromagnetic waves that can negatively influence the accuracy of the grid-alignment results. To overcome this issue, different bed types can be selected on the software's GUI to better compensate for the interference. Specifically, the bed-type selection (intensive care units vs. emergency departments) is primarily based on the thickness of the mattress on top of the bed metal frames.

Definition of Optimal Grid-Operation Range

The grid built inside the grid holder has a center focal distance of 112 cm, a grid ratio of 8:1 and a frequency resolution of 80 lines per centimeter.

The optimal grid-operation range built inside the TGA software is determined by the minimum performance requirement for image-quality improvement. The grid performance is characterized in terms of the signal-to-noise ratio improvement factor (SIF)[8]. The higher the SIF value, the better the performance. The benefit of using the grid diminishes when the SIF value equals 1.0. The optimal grid-operation range at a particular SGD is defined as the maximum allowable lateral (across the grid-line direction) misalignment in the X-ray source position, at which the minimum SIF value across the detector's effective imaging area would be greater than 1.0.

Summary

Anti-scatter grids improve radiography image quality, and the benefit of grid usage can be realized in digital radiography with less exposure technique increments. The CARESTREAM Tube and Grid Alignment System for the DRX-Revolution is fully integrated with the radiographic technologist's normal workflow, and provides easy and intuitive guidance for X-ray-source alignment to achieve consistent and optimal image quality.

References

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