Clinical Evaluation of a Photon-Counting Tomosynthesis Mammography System

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Abstract. Digital breast tomosynthesis promises solutions to many of the problems currently associated with projection mammography, including elimination of artifactual densities from the superposition of normal tissues and increasing the conspicuity of true lesions that would otherwise be masked by superimposed normal tissue. We have investigated the performance of a novel tomosynthesis system in a clinical setup. The novel system uses 48 photon counting, orientation sensitive, linear detectors which are precisely aligned with the focal spot of the x-ray source. The x-ray source and the digital detectors are scanned in a continuous motion across the patient; each linear detector collecting an image at a distinct angle. The results from an assessment of image quality and the initial clinical trial of this device are presented. Initial results provide anecdotal evidence supporting the superiority of tomosynthesis over projection mammography.

1 Background

There are a number of problems currently associated with projection mammography, including decreased conspicuity of true lesions that are masked by superimposed normal tissue and artifactual densities from the superposition of normal tissues [1]. Tomosynthesis is a promising solution to overcome these problems [2-5]. However, tomosynthesis systems based on area flat-panel detectors themselves suffer from a number of fundamental limitations. First, the requirement of sequential image acquisition limits the number of images acquired; acquiring an insufficient number of images results in image artifacts [6, 7]. Second, electronic noise, ghosting and lag found in each of the source projection images are added in the reconstruction process, resulting in excessive noise in the reconstructed images. Third, the long readout time of current flat panel detector technology results in image blurring, both from patient motion, and from the continuous scanning motion used in some systems.

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2 Imaging System

A novel tomosynthesis system has been developed [6-10]. The system uses 48 photon-counting, orientation sensitive, linear detectors which are precisely aligned with the focal spot of the x-ray source. The x-ray source and the digital detectors are scanned in a continuous motion across the patient; each linear detector collecting an image at a distinct angle.

The 48 simultaneously collected images are of very high image quality due to several special characteristics of this detector technology. First, the detectors are insensitive to scattered radiation; the detector geometry ensures that only primary photons emanating from the focal spot of the x-ray source will elicit a response from the detector. Second, the detector does not contribute any electronic noise; the strong gaseous amplification of each photon interaction allows a simple threshold to exclude electronic noise from being counted and included in the final image. Third, the image pixels are very small (60 µm) avoiding motion blurring from long scanning times of each sub-image. Finally, the detector technology does not have any residual image, ghosting or blooming artifacts.

Data appropriate for tomosynthesis is acquired over a region 24x30 cm^2 within 15 seconds. The resulting 48 projection images are then reconstructed using filtered back-projection to produce a volumetric data set of tomographic images. The images are presented on a dedicated primary review workstation for interpretation.

The imaging system is typically operated with a tube potential of between 30 and 40 kVp with a W-target anode and Al filtration. The mean glandular dose for a tomosynthesis image is typically less than or equal to a normal film/screen mammogram. The system is shown in Figure 1.

Fig. 1. The imaging system is shown. The system is capable of both projection mammography and tomosynthesis. The system is wider than conventional systems to accommodate the scanning detector and x-ray source.