Mammography Tomosynthesis System for High Performance 3D Imaging

Jeffrey W. Eberhard[1], Douglas Albagli[1], Andrea Schmitz[1], Bernhard E.H. Claus[1], Paul Carson[2], Mitchell Goodsitt[2], Heang-Ping Chan[2], Marilyn Roubidoux[2], Jerry A. Thomas[3], and Jacqueline Osland[3]

[1] GE Global Research, Niskayuna, NY
eberhard@research.ge.com
[2] University of Michigan, Ann Arbor, Michigan
[3] Via Christi Regional Medical Center, Wichita, Kansas

Abstract. Tomosynthesis provides a major advance in image quality compared to conventional projection mammography by effectively eliminating the effects of superimposed tissue on anatomical structures of interest. Early tomosynthesis systems focused primarily on feasibility assessment by providing 3-dimensional images to determine performance advantages. However, tomosynthesis image quality depends strongly on three key parameters: 1) detector performance at low dose, 2) angular range and number of projections acquired in the tomosynthesis scan, and 3) reconstruction algorithm processing characteristics used to create slice images from the measured projections. In this work, a new GE mammography tomosynthesis research system was developed that incorporates key improvements in each of these three areas compared to an early feasibility prototype system in use at Massachusetts General Hospital from 2000 to 2004. The performance gains that can be achieved by these enhancements are characterized, and clinical images acquired with the system at the University of Michigan Cancer and Geriatrics Center are presented. The advanced research system also provides the ability to acquire mechanically co-registered x-ray tomosynthesis and ultrasound images of the breast, and initial dual modality images are also presented.

1 Method

An x-ray tomosynthesis/ultrasound dual modality prototype system suitable for clinical evaluation has been developed to assess the potential to further improve breast cancer diagnosis. The tomosynthesis system is based on the Senographe DS image chain (GE Healthcare, Milwaukee, WI). Key x-ray subsystems include the x-ray source (tube and generator), the detector, the patient positioner, and the reconstruction and review hardware. The tube and generator from the Senographe DS digital mammography system have been modified to provide 50% higher current on the Rh target. This allows shorter x-ray exposure times and minimizes the possibility of patient motion during the tomosynthesis exam.

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The detector is a high performance, next generation a-Si/CsI flat panel design that achieves significant improvement in DQE at typical tomosynthesis dose levels [1]. It consists of a matrix of 1920 x 2304 pixel elements at a pitch of 100um. In order to enable low dose imaging, the noise floor of the detector was significantly reduced by altering the ratio of the electronic noise (EN) to the conversion factor (CF, signal per incident x-ray). This ratio describes the electronic noise of the detector in units of x-rays and governs how the DQE falls off with decreasing exposure (Figure 1). While 12-24 x-rays of noise may be acceptable for current 2D screening applications, 3-6 x-rays of noise are required for tomo applications, which may be acquired at 10 to 20 times lower dose per projection than a standard mammogram. By optimizing the scintillator and optical transport properties of the flat panel and adding a storage capacitor at each pixel, this electronic noise reduction was achieved while expanding the overall dynamic range of the detector.

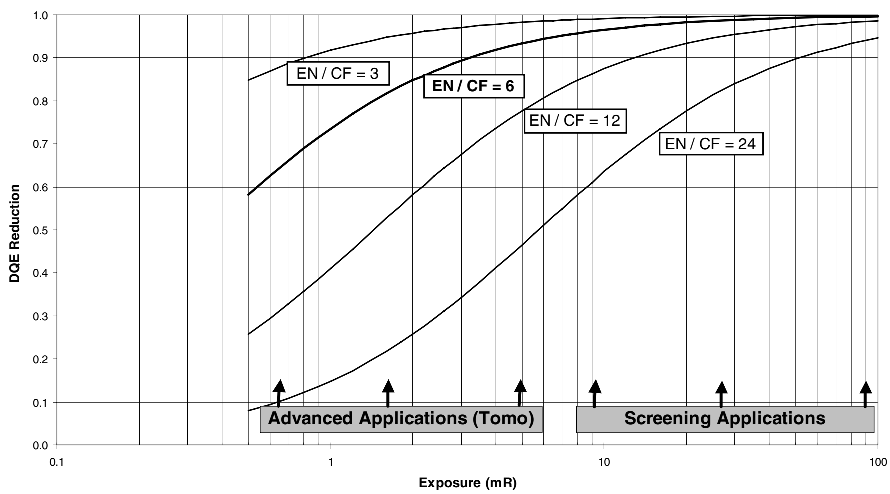

Fig. 1. DQE reduction factor vs. exposure as a function of electronic noise ratio (EN/CF) [1]

A specialized patient positioner was designed to provide a more flexible acquisition geometry with provision for dual modality XR/US imaging. During the tomosynthesis acquisition, the tube traverses an arc above the patient, with the point of rotation at the level of the breast support. The compressed breast remains stationary above the non-rotating detector surface during the examination. The system acquires 21 projection images over a wide angular range of 60 degrees in under 8 sec in order to minimize patient motion during the exam. Larger angular range provides greater depth resolution and more projections reduce the level of streak artifacts in the images. The prototype system installed at the University of Michigan is shown in Fig. 2.