Tomographic Dual Modality Breast Scanner

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Abstract. We are developing a breast scanner that obtains co-registered dual modality tomographic images of the breast using x-ray imaging (digital breast tomosynthesis) and gamma emission imaging (limited angle breast SPECT). The project is a collaborative effort among the Jefferson Lab (Newport News, VA), Dexela Ltd., (Sudbury MA), and the University of Virginia (UVa) (Charlottesville, VA). The scanner is currently undergoing pilot clinical evaluation at UVa's Breast Care Center. Here we report on the design of the scanner, choice of acquisition parameters, and present some early phantom and human breast images.

Keywords: dual modality, tomosynthesis, limited angle tomography, molecular breast imaging, breast scintigraphy.

1 Background

Digital tomosynthesis [1,2,3,4] and dedicated breast CT [5,6,7] are being explored as methods for reducing the superposition of structures that occurs in planar breast imaging, thereby improving lesion visibility while keeping the radiation dose to the breast much less than would occur in whole-body CT. At the same time, functional breast imaging modalities are being sought to provide information that is complementary to the structural information of x-ray imaging. A number of investigators are developing nuclear medicine-based systems that are dedicated to breast imaging. Both dedicated positron imaging systems for breast PET [8,9,10,11,12] and dedicated single gamma imaging systems for breast scintigraphy [13,14,15,16,17] are being developed. We are developing a dual modality tomographic (DMT) breast scanning system that integrates x-ray transmission tomosynthesis and gamma ray emission tomosynthesis into a single unit. The imaging objective is to obtain volumetric x-ray and gamma ray image data sets that can be viewed as a single set of fused dual modality slices or as correlated structural-functional slice pairs if desired.

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2 Methods

2.1 Scanner Description

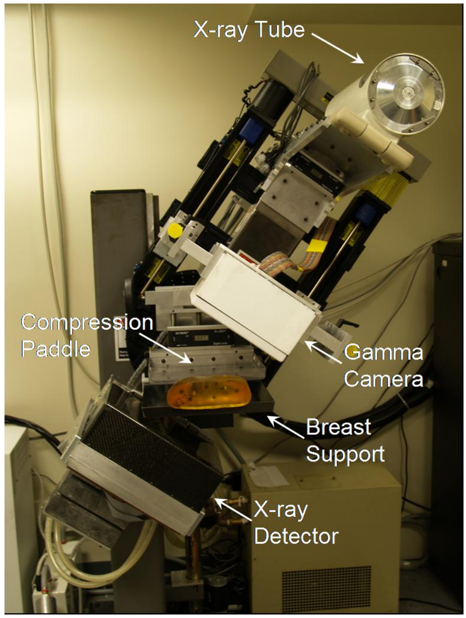

Fig. 1. The DMT breast scanner. A dedicated high resolution gamma camera is mounted on a translation stage attached to the gantry arm. Shown above is the configuration during gamma imaging. The camera is positioned out of the x-ray beam during x-ray imaging.

The DMT scanner, built in collaboration with Jefferson Lab (Newport News, VA) and Dexela Ltd. (Sudbury, MA) is housed in UVa's Breast Care Center (BCC) (Figure 1). It has evolved from the prior development of an upright dual modality planar breast scanner [18,19]. In the current DMT scanner, breast support and compression mechanisms that are independent of the gantry arm support the breast near the arm's axis of rotation (AOR) and permit multiple-view, tomographic image acquisition for both modalities [20]. The DMT employs full isocentric motion, in which both the tube and detector rotate around a common AOR [21]. The gantry, built by Dexela, uses a Parker model CM232FJ-114828 servo motor coupled via a worm gear to the gantry arm. The scanner's x-ray component includes a high output, oil-cooled tungsten target x-ray tube (Varian model RAD 70) and a CCD-based full field digital x-ray detector (field of view (FOV) = 20 cm x 30 cm) that was developed under NCI funding [22]. A 50 micron thick rhodium filter provides external filtration. For tomosynthesis reconstruction, statistically based iterative algorithms are used to minimize the noise in the reconstructed image. The algorithms compare the predicted and observed projection data to correct the model while preventing overfitting of the noise in the data.

A gamma camera (FOV = 15 cm x 20 cm), built by the Jefferson Lab, is mounted on the gantry arm between the x-ray tube and the breast support via a pair of parallel, motorized linear translation stages to permit the camera to be moved parallel to the long axis of the gantry arm. This permits the distance between the collimator surface and the axis of rotation (AOR) of the gantry arm to be continuously varied. Minimizing the radial distance from the axis of rotation (AOR) of the gamma camera for each view maximizes the SNR in the reconstructed image because of improved spatial resolution and higher lesion contrast [20]. The camera's chest-anterior position is adjusted by sliding it manually along two slider rails whose ends are mounted on the two translation stages. During x-ray imaging the camera is positioned close to the gantry arm out of the beam. It is then repositioned in the posterior direction for