Three-Dimensional Digital Breast Tomosynthesis in the Early Diagnosis and Detection of Breast Cancer

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Abstract. This paper presents doctoral thesis of three-dimensional digital breast tomosynthesis in the early diagnosis and detection of breast cancer. The purpose is to prove that digital breast tomosynthesis has the potential to provide clinically important information, which cannot be obtained with conventional breast imaging methods. Three-dimensional digital breast tomosynthesis seeks to (1) determine whether a mammographic finding is the result of a 'real' lesion or the superimposition of normal parenchyma structures, (2) detect subtle changes in breast tissue, which might otherwise be missed, and (3) to reduce the number of biopsies performed as well as verify the correct biopsy target if the procedure is needed. This study presents digital breast tomosynthesis in diagnostic mammography by comparing digital breast tomosynthesis with screen-film and digital mammograms clinical performance, evaluates Tuned Aperture Computed Tomography capability as a 3D breast reconstruction algorithm in the limited angle tomosynthesis system, and demonstrates technical performance of a real-time amorphous-selenium flat-panel detector in full field digital breast tomosynthesis. The results indicate that breast tomosynthesis has the potential to significantly advance diagnostic mammography. Tomosynthesis of the breast will increase specificity. Study also suggests that tomosynthesis might facilitate the detection of cancers at an earlier stage and a smaller size than is possible in two-dimensional mammography [1].

1 Introduction

Two-dimensional (2D) mammography plays a most important role in all aspects of breast cancer detection, diagnosis and treatment. Although it is well known that 2D mammography has limitations and it is not capable of detecting all breast cancers, there is no question that mammography is an important imaging technique for detecting and diagnosing breast cancer. Challenges of 2D mammography are structured noise, which is created by the overlap of normal dense tissue structures within the breast. This may obscure the findings causing lesions to be missed (reduction of diagnostic sensitivity). Breast tissue may also simulate the presence of a cancer that does not actually exist. This causes a loss of diagnostic specificity. Currently 2D mammography is the only x-ray imaging modality accepted for breast cancer screening, but for years researchers have tried to find improved technologies and new methods to

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supplement 2D mammography and provide better sensitivity and specificity. Digital breast tomosynthesis (DBT) is a method that was first described many years ago, but could not be easily applied until the development of fast read-out digital detectors. The goal of breast tomosynthesis is to make available a method for screening and diagnostic mammography, which provides higher sensitivity and specificity than routine mammography [1], [2], [3].

1.1 Digital Breast Tomosynthesis

The ability to produce tomographic sections through the body with x-rays to eliminate structured noise was developed decades ago. In the late 1970's, linear and poly-cycloidal tomography was used to evaluate many organ systems. During exposures that lasted several seconds, the x-ray tube was moved in one direction while the film receptor was moved in the opposite direction. Only structures in the plane of interest stayed perfectly aligned and in sharp detail during the exposure, while structures that were out the plane on interest were blurred by the motion. Only the structures at the fulcrum of movement stayed registered. To see another plane, the fulcrum of the motion was shifted, and another exposure was made. Commonly used to evaluate other organ systems, such as kidney and chest, this technique was not feasible for breast evaluation. Breast tomosynthesis acquires multiple images as the x-ray source moves through an arc above the stationary compressed breast and digital imaging detector. As the acquisition begins, the beam moves through a series of positions in different degrees. Once the projections of the breast are obtained during a tomosynthesis sequency, they must be reconstructed into a data set and displayed in a manner suitable for review by a radiologist [2], [4], [5].

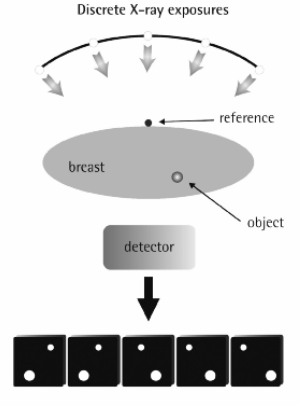

Fig. 1. Principle of breast tomosynthesis imaging

With stereotactic tubehead movement, the digital mammography system acquires a number of projection images with different angles, shown in figure 1. The total arc varies between 30˚ to 60˚. The number of projection images varies from 7 to 25