Image Qualities of Phase-Contrast Mammography

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Abstract. A digital full-filed mammography system using phase-contrast technique has been developed. The system consists of a dedicated mammography unit, a computed radiography unit with a sampling rate of 43.75 microns, and a photothermographic printer with a printing rate of 25 microns for photothermographic film with the maximum optical density of 4.0. The sharpness of the output image is improved with an edge effect due to phase contrast and magnification. The image noise is reduced by an air-gap method with no bucky. In this paper, the image qualities of the phase-contrast mammography are described for full-filed mammography and spot-compression at 1.5x magnification.

1 Introduction

In 1895, Röntgen discovered an x ray, however, the wave nature has been out of attention in x-ray medical imaging till 1991 when Somenkov and co-workers reported that refraction of x rays can increase contrast of x-ray images [1] ; this is "phase-contrast imaging". The principle of phase-contrast imaging is illustrated in Fig.1.

The phase-contrast imaging has been intensively studied employing x rays from synchrotron and micro-focus x-ray tubes in 1990's, and realized recently in mammography for clinical use. Utilization of this technique in full-field digital mammography is attempted for a goal to improve the image quality so as to be equal to or better than that of screen/film (SF) mammography. It has been reported that the phase-contrast mammography (PCM) system provides better detectability of micro-calcifications and masses in diagnostic images than SF mammography [2] .

Using the PCM system, we empirically assessed improvement of image-sharpness with an edge effect due to phase contrast, and magnification for full-filed mammography and spot compression at 1.5x magnification. Additionally, the image noises were measured for full-filed digital phase-contrast mammography comparing with conventional contact digital mammography.

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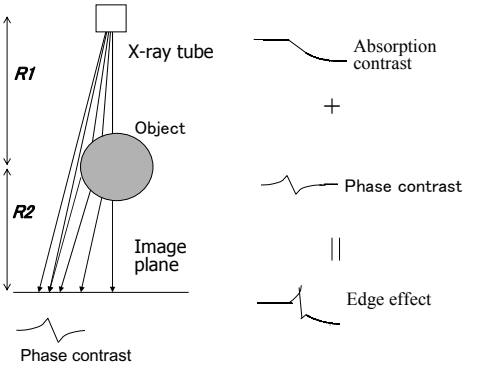

Fig. 1. Edge effect takes places with superimposition of phase contrast on an absorption contrast image. Note that the image plane should be away from the object in phase-contrast imaging.

2 Method

2.1 PCM System

The PCM system consists of a mammography unit, a computed radiography (CR) unit, and a photothermographic printer as shown in Fig.2. The mammography unit for phase-contrast imaging has a nominal 100 μm focal spot in a configuration of a 0.65 m distance from the focal spot to the object holder (R_1) and 0.49 m for the distance from the object holder to the storage phosphor plate holder (R_2) with no anti-scatter x-ray grid. Because the phase-contrast imaging is set at 1.75x magnification for full-field mammography, the storage phosphor plate used was 14x17 inches in size. For spot compression at 1.5x magnification, R_1 is 0.43 m, and R_2 is 0.71 m, resulting in a magnification ratio of 2.65 in image-acquisition. Note that the distance of $R_1 + R_2$, SID, is 1.14 m, equal to that for full-field digital PCM.

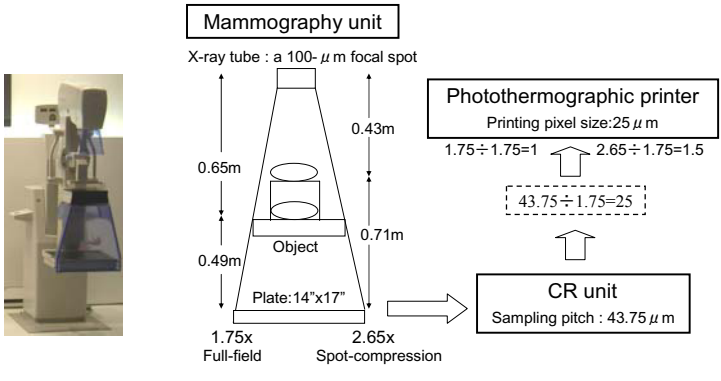

Fig. 2. Schematic diagram of a digital phase contrast mammography system