Approximately 50%-70% of malignant tumors in the breast are known to contain clusters of microcalcifications, which are small deposits of calcium compounds (mostly oxalates) varying in size from 100-400 microns\(^1\). In early stages of carcinoma, microcalcifications sometimes are the only signs of problems. It is therefore believed that discernability of cluster patterns in x-ray mammograms will serve as a marker for breast cancer in mammograms where the tumors themselves might not be convincingly visible. As a follow-up to our efforts at assessing the performance of new mammography modalities through image simulation by Monte Carlo, we are now studying the potential for imaging of microcalcification cluster patterns by a new digital mammography system, namely, the Fischer Senoscan\(^{TM}\).

This study uses the MCMIS Monte Carlo code written and validated by one of the authors [DEP]. This code calculates images and dose for two different modalities, one of which is the Senoscan\(^{TM}\). The source of x rays is a high intensity x-ray tube operated typically at about 40 kVp. The low-energy photons are filtered out and the rest are collimated through a slot collimator to produce effectively a line source. The breast is compressed between two curved paddles and below it is a detector with a line CCD array. The collimator slot at the source and the detector scan across the breast to produce the digital radiograph of the breast. A description and validation of MCMIS for the simulation of Senoscan images of mammography phantoms can be found elsewhere\(^2\).

Spatial resolution of calcification clusters in a mammogram is affected by the hardware and the operating parameters of the system as well as by the size and composition of the breast. The major hardware item in this regard is the resolution of the digital detector. Some of the systems use 100 micron pixels while the Senoscan uses 50 micron pixel size. Some experimental detectors have even achieved 25 micron pixels. The kVp of the x-ray tube also will affect the resolution and contrast because of the changes in scattering.

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Similarly breast thickness and its glandular tissue/fat content can also change the scattering effects, thus affecting both contrast and resolution. One of the factors that discourage women from getting routine screening is the breast compression and it will be beneficial if the degree of compression can be reduced. We believe that the loss of resolution and contrast resulting from varying the breast size in our simulation studies will serve as an indication of the effect of reduced compression. The boundary effects of the breast are expected to not affect the calcification simulations since the calcification phantom is only a little over 1 cm x 1 cm in total size and it is placed at the center of the breast whereas the breast size is 12 cm along the chest wall and 15 cm perpendicular to the chest.

We have devised a computational phantom of microcalcification pairs embedded in breast tissue for our image simulation study. Fig. 1 shows the phantom consisting of pairs of different sizes of calcifications, each one in a pair separated by a given distance. One member of each pair is 400 microns in diameter and the other one varies between 50 microns and 400 microns. The separation distance within the pairs varies from 25 microns to 200 microns.

Simulated images of the phantom in a breast consisting of 50% glandular/50% fatty tissue (typical assumed composition for older women) for breast thickness ranging from 4 cm - 7 cm have been generated for the standard operating conditions of the Senoscan tube. The detector pixel size is a variable of interest. Figure 2 shows the image for a 100 micron pixel size and a 4 cm thick breast. Figure 3 shows the line scans across the top (25 micron gap between pairs of different radii) and bottom (200 micron gap between the pairs) rows of the phantom. Notice that for this pixel size, calcifications smaller than 200 microns next to a 400 micron calcification are not resolved at all even with a separation distance of 200 microns. Similar images for a 50 micron detector shows improved resolution for the same separation distance. These types of results are valuable in performance evaluation of digital mammography systems. Results for other values of breast thickness and tube operating conditions will be presented at the conference.

REFERENCES:

Figure 1. The computational phantom for the study of resolution of microcalcification clusters.
Figure 2. The simulated image of the phantom as would be seen on a Fischer Senoscan™ digital mammography system for a 100-micron detector pixel size.
Figure 3. Line scans of the image along the centers of the top and bottom rows showing the degree of resolution to be expected as the space between the calcification pairs increases from 25 microns to 200 microns.