# MR Guided Optical Tomography of the Breast:
## Dependence of Image Quality on View Angle

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### Introduction and Methods

An important goal in our laboratory is the development of optimized data collection and analysis schemes that yield accurate and tractable solutions for the problem of optical tomography of the breast. To accomplish this we have adopted use of MR–derived priors as a means of generating anatomically accurate models. We choose the MR method because of the excellent contrast obtained for soft tissues and in order to assess the practicality of possible combined optical/MR measurements.

The basic scheme involves carefully segmenting 3–D MR data according to tissue type (primarily, adipose and parenchymal tissue) and assigning estimates of the absorption and scattering coefficients to each of the types. By adjusting these coefficients in specified regions, "simulated pathologies" can be introduced, whose size, location, number and contrast with the background tissue are varied. Segmented maps with and without these inclusions are evaluated using diffusion and transport–based solvers to compute detector readings and associated weighting functions (imaging operators) for specified tomographic data collection schemes. Typical 3–D data sets are discretized into 50–350 thousand voxels, depending on the value of assigned coefficients. Efficient solutions to the diffusion equation are obtained using multigrid methods [1]. The corresponding volume of the breasts examined are between approximately 200–1600 $cm^3$. Solutions to the inverse problem are computed using previously described algebraic methods that compute first–order or iterative solutions to a linear perturbation equation [1–3].

The condition of the weight matrix, and hence stability of computed images, can be expected to vary with the available views. In this report, we have explored this dependence for several illumination/detection geometries.

### Results

A representative MR slice and segmented image of the breast used in these studies is shown in Figure 1. The geometry of the simulated tomographic data collection scheme is shown in Figure 2. Depicted are twenty sources and, for each, twenty collocated detectors oriented in a coronal plane. Figure 3 shows the location of the added inclusions. Figure 4 shows increasing restrictions to a full view (twenty sources, twenty detectors) that have been tested, including limited forward and backward views, sparse views and a "compressed" view. Corresponding 2–D images obtained for these views are shown in figure 5. Images shown contain 1,584 unknowns.

### Discussion

Results obtained show that with respect to the full view, increasing restriction of the view accomplished by deleting detector positions in the forward or backward orientation, deletion of sources and detectors on the sides (*i.e.*, simulated compressed view) or by generating a uniformly sparse view introduces distortion in the computed images. Interestingly, the effect is to underestimate the distance between the two added inclusions. In the case where only ten sources and ten detectors were used, only artifact is recovered. Results obtain suggest that sufficiently dense full tomographic views may be necessary to obtain images that are at least qualitatively accurate.

[1] Y. Yao, Y. Wang, Y. Pei, W. Zhu, J. Hu, R. L. Barbour, "Frequency domain optical tomography in human tissue," SPIE Proceedings vol. 2570, in press.

[2] R. L. Barbour, H. L. Graber, Y. Wang, J. Chang, R. Aronson, "A perturbation approach for optical diffusion tomography using continuous–wave and time–resolved data," SPIE Institutes vol. IS11, pp. 87–120, 1993.

[3] J. Chang, H. Graber, R. L. Barbour, R. Aronson, "Recovery of optical cross section perturbations in dense scattering media using transport–theory–based imaging operators and steady–state simulated data," *Applied Optics*, in press.

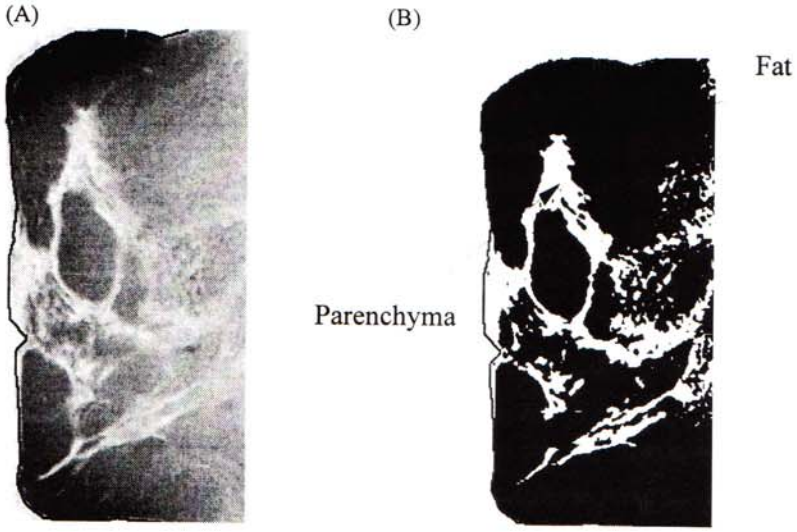


Figure 1. A representative MR slice (A) and segmented image (B) of the breast used in these studies.

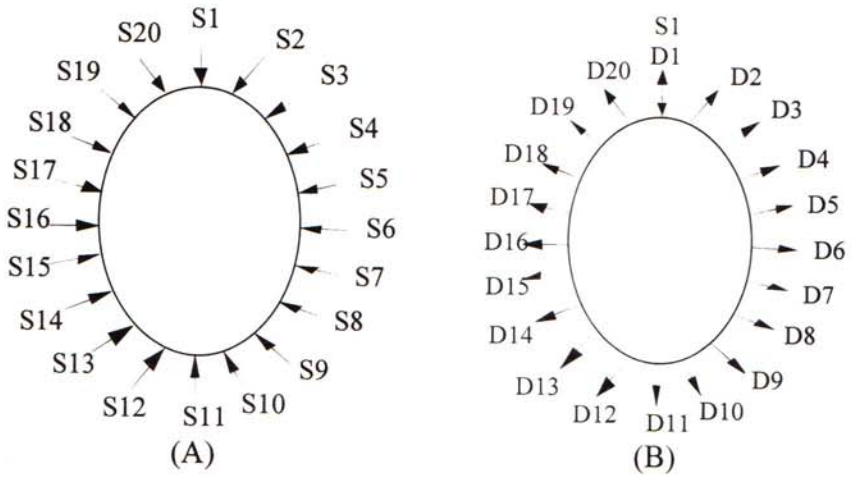


Figure 2. Illustrations of the source–detector pairs used in the study of the MR breast images: (A) twenty source locations. (B) twenty detector locations for source 1 (S1).

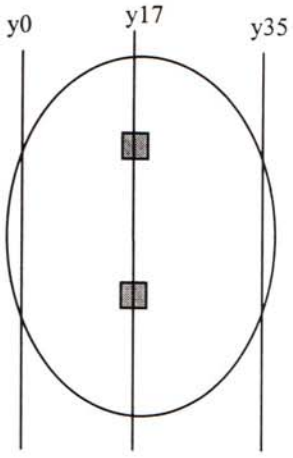


Figure 3. Illustration of the locations of two pathologies introduced in the upper and lower portions of the breast phantom.

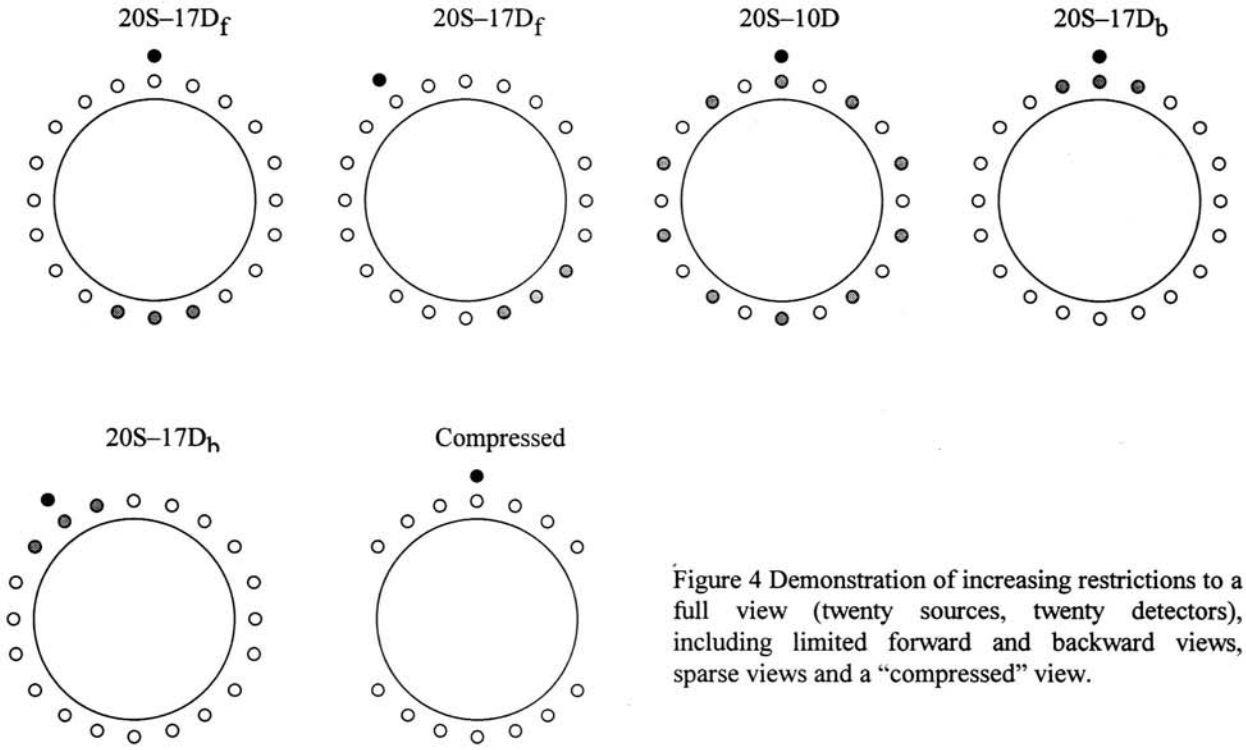


Figure 4 Demonstration of increasing restrictions to a full view (twenty sources, twenty detectors), including limited forward and backward views, sparse views and a "compressed" view.

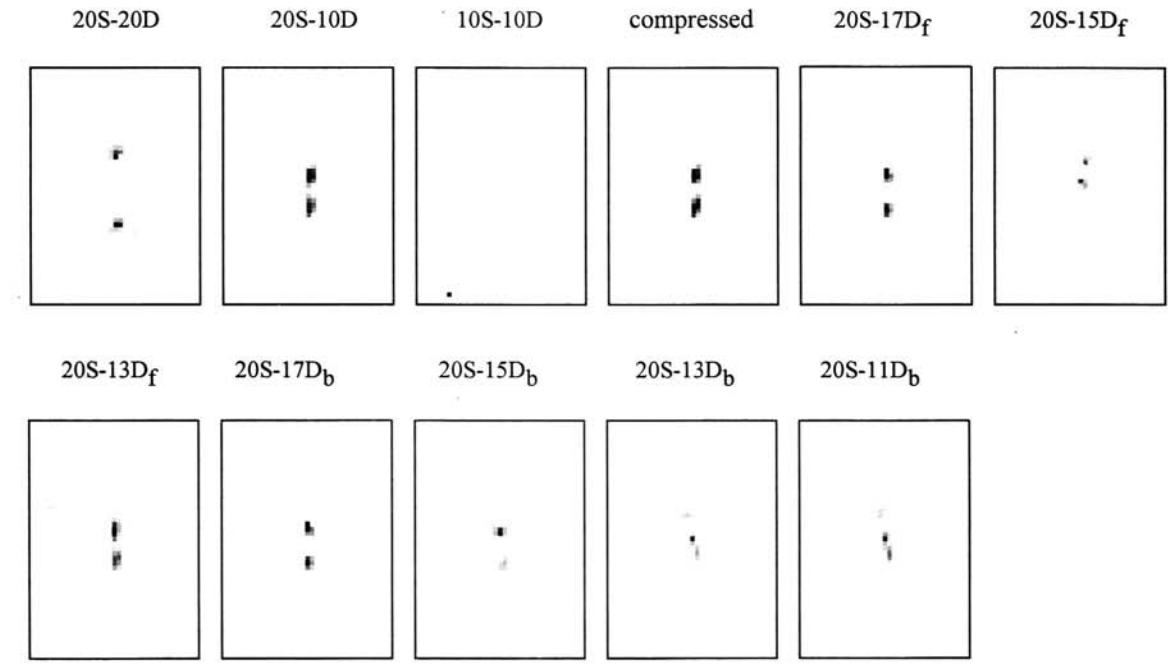


Figure 5 2–D reconstructed images obtained for these views in Figure 4. Each image shown contains 1,584 unknowns.