Mathematical models for breast cancer detection with microwave tomography are cheaper and less risky

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The most popular method of breast cancer detection today is X-ray mammography, which takes images of a compressed breast by low-dose ionizing radiation. However, there are several disadvantages to using X-rays for breast cancer screening, chief among them being the invasivity of radiation and the high costs, which limit their wide use and can deter women from getting them. In addition, depending on the age of the patient and tissue density, X-ray mammograms often result in false positives and negatives.

Microwave tomography can provide a cheaper and less risky alternative to X-ray mammography. In a paper published today in the *SIAM Journal on Applied Mathematics*, the authors describe a mathematical model for imaging tumors in the breast using microwave tomography. Microwave tomography detects cancers by measuring inhomogeneities in the electrical conductivity of breast tissue. An array of low-power microwaves are transmitted into the breast from different positions and the resulting scattered signals are collected by antennas surrounding it. The malignant-to-normal tissue contrast arises because cancerous cells have higher water content, and are hence stronger scatterers than normal tissue.

The electrical properties measured by microwaves are sensitive to physiological parameters such as water content, temperature and vascularization. In addition, they can give an estimate of mammographic breast density, which is a crucial factor in evaluating a patient's risk of breast cancer. The distribution of these electrical parameters in space is used to reconstruct the image of the breast with the help of carefully designed algorithms.

There is room for improvement in the mathematical method that currently exists for image reconstruction in microwave tomography. The problem to be solved is an inverse scattering problem. At microwave frequencies, the inverse problem is difficult to solve accurately because it is highly nonlinear. In addition, it is an ill-posed problem, which means that it does not have a solution in the strict sense, the solutions are not usually unique, and may not depend continuously on the data.

Different approaches have been used to circumvent these. One involves linearizing the problem, but this can result in significant loss of accuracy. A second approach uses nonlinear optimization and relies on initial apriori information on object shape and electric properties. While this yields more accurate results, its reliability depends on the accuracy of the initial information and is computationally expensive.

A more recent approach uses a qualitative method utilizing "sets" of linear integral equations of the first kind. While these are faster and don't require apriori information, they can only provide estimates for sets of points. In this paper, the authors use a linear sampling method in combination with a gap functional to take into account near fields instead of far fields. This results in higher accuracy.

More information: Access to the paper is available at: www.siam.org/journals/newpost.php

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