

RECENT DEVELOPMENTS IN TISSUE SENSING ADAPTIVE RADAR

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Tissue sensing adaptive radar (TSAR) has been proposed as a method for breast cancer detection (J.M. Sill and E.C. Fear, *Electronics Letters*, **41**, 113-115, 2005). This method exploits the hypothesized difference in electromagnetic properties of healthy and malignant breast tissues (S.C Hagness et al, *IEEE Transactions on Biomedical Engineering*, **45**, 1470-1479, 1998). TSAR involves illuminating the breast with a pulse of microwaves, recording reflections, and isolating reflections from tumors. A focusing step provides a three-dimensional map indicating the location of strongly scattering objects. Several challenges are inherent in this technique. First, an ultra-wideband signal is used, as a bandwidth of several GHz is desired for reasonable resolution, while the upper frequency is limited due to increasing attenuation in tissues with frequency. The pulse used in TSAR is a differentiated Gaussian signal with significant energy content between 1.4 GHz and 8.7 GHz. This presents antenna design challenges. Second, the reflected signal contains a dominant contribution from the skin. This reflection must be reduced to permit detection of small tumors in the breast. Finally, reflections arise from structures in the breast, such as glandular tissues. Reflections from structures other than the tumor are considered to be clutter. Effective clutter reduction is required to permit robust detection of small tumors. To date, the challenges of TSAR have been primarily investigated using finite difference time domain simulations of simple breast models. Recently, work has focussed on experimental testing of a prototype system that permits exploration of different antenna designs and algorithms for skin sensing and clutter reduction.

The prototype system consists of a tank, which contains an immersion liquid (canola oil), as well as the antenna under test (J.M. Sill and E.C. Fear, *2005 IEEE MTT-S Int. Microwave Symposium Digest*, 4 pp., ,2005). The simple breast model is cylindrical in shape, and consists of materials that mimic the electromagnetic properties of skin, fatty breast tissues and tumors. The breast model is rotated in order to represent scanning the antenna around the breast, and measurements are taken with a vector network analyzer (Agilent 8719ES, Agilent Technologies, Palo Alto, CA, USA). TSAR algorithms are applied to reflections measured at 16 antenna locations, and an image of the plane perpendicular to the axis of the breast model and containing the tumor is created. A 1 cm diameter tumor is detected with a signal-to-clutter ratio of 10 dB. The prototype system is also used to test advanced algorithms for sensing the location and thickness of the skin. Reflections are collected from a metal sheet in order to estimate the system response. This response is deconvolved from reflections observed from a sheet of the skin material. Results indicate location and thickness estimates with errors of 1.1% and 27.5%. This represents a slight improvement in location error and a significant reduction in thickness estimate error (factor of over 3.5) when compared with the previous method of skin sensing. Overall, work with the prototype system demonstrates the successful application of TSAR algorithms to experimental data and provides a test bed for evaluating improvements to the TSAR approach.

Abstract Submission Form

2006 National Radio Science Meeting

Abstract: fear15163

Date Received: September 15, 2005

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4. I - Invited Paper, Program chair:
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5. No special instructions