ULTRAWIDEBAND MICROWAVE BREAST CANCER DETECTION: SPACE-TIME BEAMFORMING FOR 3-D MRI-DERIVED NUMERICAL PHANTOMS

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Microwave imaging is a promising modality for breast cancer detection that exploits a dielectric contrast between malignant and healthy breast tissue. One microwave-based technique that has been proposed for detecting breast tumors is space-time beamforming (Bond, *et. al*, *IEEE T-AP*, **51**, 1690-1705, 2003). Beamforming is a spatial filtering technique used to synthetically focus array data. An image of the focused energy is plotted where high energy regions imply the presence of strong scatterers such as tumors.

In this paper we apply beamforming to computed backscatter data from 3-D MRI-derived numerical breast phantoms. Tissue composition in these phantoms is dependent on two factors. The first is the tissue architecture derived from an MRI which defines the spatial distribution of fatty and fibroglandular tissues in the breast. The second factor is the assignment of dielectric properties to represent the types of breast tissue. Further studies are needed to determine a definitive method for mapping the MRI intensity to representative dielectric properties, but for a given MRI we consider two possible methods. One method is a uniform mapping (UM) which linearly maps pixel intensity to a range of dielectric values. The second method that we consider is a piecewise linear mapping (PWLM) which partitions the range of MRI intensities into multiple intervals and each interval is linearly mapped to a distinct range of dielectric properties values. The PWLM is based on the assumption that fibroglandular and fatty tissues are distinct and their respective dielectric constant and conductivity may occupy non-adjacent ranges. In the non-adjacent case an interval of intermediate-intensity pixels is transformed to a transitional range (between fat and fibroglandular) of dielectric properties.

We compare the mappings from the perspective of clutter and tumor detectability using beamforming. An MRI for a patient with heterogeneously dense breast tissue is selected and we create 3-D MRI-derived numerical phantoms using the UM and PWLM. The overall span of assigned dielectric properties is held constant; however, while the UM leads to smooth transitions in the distribution of dielectric properties, the PWLM mapping may induce sharper transitions that give rise to higher levels of clutter relative to the UM. Beamformer images reflect the elevated clutter levels as a reduction in the signal to clutter energy ratio for a detected tumor.

Assumptions regarding dielectric properties distributions throughout heterogeneous breast tissue must be made in theoretical studies of any microwave imaging method. We have considered two possible distributions of the dielectric properties and we note that the PWLM leads to a more challenging detection problem.

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