A MATCHED-FILTER FDTD-BASED TIME REVERSAL APPROACH FOR MICROWAVE BREAST CANCER DETECTION

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The feasibility of microwave breast cancer detection with a time reversal algorithm is examined. This algorithm is based on the finite difference time domain (FDTD) method, and compensates for the wave decay and therefore is suitable for lossy media. In the present work, we consider a two-dimensional (2-D) breast model based on magnetic resonance imaging (MRI) data, and examine the focusing abilities of a time reversal mirror (TRM), comprised of an array of receivers with a single, ultra-wideband pulse excitation. Without special considerations, resolving small (3 mm diameter) tumor-like scatterers requires very short duration pulses. This requirement demands hardware with unusually high performance. We propose a way to overcome this difficulty based on the observation that the amplitude and phase information of the tumor response is sufficient to achieve focusing.

We first assume that the tumor/scatterer response is known exactly, and show that the time reversal process is robust to background uncertainties. In particular, focusing is achieved even when the time-reversed model ignores a priori information such as breast tissue inhomogeneities or skin layer thickness and dielectric properties. We then examine the much more challenging realistic situation where the target response is not known and can only be estimated from the total (clutter-dominated) signal. The detection and localization problem is divided into two distinct processes: 1) a method that can identify and estimate the tumor response from the data is required; 2) this estimated tumor response at each receiver is backpropagated through the medium, and the wave is focused to the tumor/scatterer location. A matched filter approach to solve the signal-processing problem of the first process is proposed and applied to the TRM data, and FDTD time reversal is used to backpropagate the output of the matched filter algorithm. Detection and localization is achieved for different target locations, and the ability of the time reversal algorithm to avoid false alarms is demonstrated. The overall good performance of the method suggests that it is a promising new technique for microwave breast cancer detection.

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