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Breast imaging using electromagnetic (EM) waves is challenging, as illustrated by an abundant literature (not further discussed for brevity), yet lacks application in the field beyond prototype stage, e.g., [1]. In the present contribution one aims at the case of a pending breast (in opposition with the compressed breast of X-ray mammography) immersed in a coupling medium and probed by a series of antennas (emitters and transmitters as well) set in this medium, frequencies of their operation being chosen around a couple of GHz to achieve both enough penetration and still meaningful resolution. The spatial distribution of the EM parameters (permittivity and conductivity, accounting for the fact that frequency-dispersive tissues usually follow Debye-type laws) is to be retrieved so as potential anomalies be exhibited. A broad set of inversion procedures could be applied to tackle such an inverse scattering problem, refer, e.g., to [2], though it is obvious from earlier investigations that priors as those yielded by ultrasonic (US) probing [3] can be very useful. When the contrasts are as weak as those in US breast imaging (with speed of sound varying by no more than a few percents), the inversion indeed can be cast as a linear problem, and in practice simple reflectometric analyses led in the low MHz range (associated with mm local wavelengths) can provide boundaries (possibly blurred) between zones in the breast, even if not attuning for slowly changing parameters within a given zone. This is in contrast with the highly nonlinear aspect of the EM case, since contrasts can be high, in addition to the heterogeneity of the breast structure, plus the impedance jump at the skin.

Several solution methods are to be compared in this contribution (with aforementioned US priors) on a 4-zone 2-D model of breast (skin, fatty, fibroglandular and tumor tissues) and a MRI-derived one from the UWCEM Breast Phantom Repository, with due application of a Method of Moments (FFT being implemented in both forward and inverse problems to accelerate the computations). In a frequency-hopping setting, using the US boundary priors, the rather traditional Distorted Born Iterative Method (DBIM) and Contrast Source Inversion (CSI) method are employed (with proper tailoring), and their pros and cons compared in systematic fashion with those of a novel multi-binary contrast-source-based extension of a binary-constrained solution first introduced in [3] and of a Twofold Subspace-based Optimization Method (TSOM) as recently proposed with emphasis on imaging obstacles in a known inhomogeneous medium. Time permitting, from all such results, the potential of data fusion using both US and EM modalities in the course of the inversion itself instead of just introducing smart US priors will be considered, including the fact that one is faced with cm local wavelengths with EM and millimetric ones with US, which complexifies data fusion (US mapping of boundaries first is in comparison more straightforward).

References

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