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# Analysis of Optimal Microwave Imaging System and Algorithm Parameters for 3D Reconstructions of Breast Tissues

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## 1 Extended Abstract

Hybrid microwave imaging (MWI) techniques have produced promising images of numerical breast models [1], and have demonstrated the importance of prior information in reconstructing accurate geometric and dielectric tissue properties [2],[3]. Such prior information, realated to the distribution of fibroglandular tissues in the breast, is essential in full three-dimensional reconstructions, where the number of unknowns is substantial. This influences the optimal configuration of the imaging system and the parameters of the inversion algorithm.

Breast classifications range from mostly fatty tissue, to very dense fibroglandular tissue (Class 1-4). The contrast distribution in the imaging domain relative to the immersion medium background varies depending on the type of breast. The hybrid algorithm used relies on a 3D finite element contrast source inversion (FEM-CSI) algorithm. In this formulation of FEM-CSI, the contrast can be artificially reduced by introducing a patient specific, position dependent numerical background permittivity, $\varepsilon_n(r)$ into the contrast variable $\chi(r)$, such that $\chi = (\varepsilon_r(r) - \varepsilon_n(r))/\varepsilon_n(r)$. Our goal is to determine the optimal distribution and polarization of the surrounding antennas, which may change with breast classification and tumour position, so as to maximize the amount of information in the scattered field data obtained from the tumour.

We present a systematic study to optimize the parameters of the imaging system and algorithm used to reconstruct realistic 3D MRI-based numerical phantoms with varying densities and distributions of fibroglandular tissue. The study is data-driven in that the distribution of scattered field data is analyzed in a variety of different scenarios. Trends in the statistical properties, as well as the quality of the reconstructed images, are used to identify favourable incident field frequencies, antenna distributions and polarizations. These trends are also analyzed in order to determine the quality of a chosen numerical background, and to identify possible errors in prior information. Full 3D reconstructions of numerical breast phantoms with varying classifications are shown, as well as an analysis of the applicability of these methods to experimental systems using 3D printed breast phantoms. We search for the parameters of a robust system and algorithm that perform well for a wide range of breast classifications.

## References

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