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A Non-Iterative Eigenfunction-Based 3D Inverse Solver for Microwave Imaging

N. Abdollahi* , I. Jeffrey, and J. LoVetri
University of Manitoba, Winnipeg, MB, Canada,
http://home.cc.umanitoba.ca/~lovetrij/EMILab/index.html

1 Extended Abstract

Microwave imaging within resonant enclosures that are bounded by PEC walls has been of interest for various advantageous reasons [1, 2, 3, 4]. A non-iterative inversion algorithm has recently been reported in [5, 6] and demonstrated for the 2D Transverse-Magnetic electromagnetic inversion problem which consists of the recovery of the dielectric profile of a target located within an arbitrarily-shaped PEC-walled enclosure. This algorithm takes advantage of the discrete spectrum of the Helmholtz boundary-value problem associated with the enclosed region and utilizes the eigenfunctions as whole-domain basis upon which to expand all the unknowns for the inverse problem: the electromagnetic fields, the contrast sources, and the contrast variables. The electric field at a finite number of measurement locations outside the imaging domain (within the chamber) or the tangential magnetic field on the walls of the chamber can be used to provide the data for the inversion. The choice of a canonical chamber shape, such as a rectangle, allows formulating analytic basis functions and this, along with the fact that the algorithm is non-iterative, makes the computation of the eigenfunction expansion coefficients extremely fast. For example, choosing a square imaging chamber allows the use of simple sinusoidal basis functions that also help to minimize the numerical error. The algorithm has been validated using synthetically derived scattered-field data corresponding to a simplified high-contrast breast phantom; this also demonstrates the algorithm's applicability to the practical problem of breast cancer imaging. Accurate inversion results have been obtained resolving isolated objects having a separation as small as $\frac{\lambda}{30}$. Regularization is achieved using novel constraints on the contrast-sources outside the imaging domain. In this work, we present the 3D vector-field extension of the non-iterative algorithm where the formulation is in terms of electromagnetic potentials. As will be presented, the reconstruction results of testing the 3D algorithm on synthetic data for multiple low-contrast targets are in good agreement with results of a DGM-CSI algorithm [7].

References

[1] C. Gilmore, and J. LoVetri, "Enhancement of microwave tomography through the use of electrically conducting enclosures," *Inverse Problems*, **24**, 3, April 2008.

[2] M. Asefi, G. Faucher, and J. LoVetri, "Surface-current measurements as data for electromagnetic imaging within metallic enclosures," *IEEE Trans. Microw. Theory Techn.*, **64**, 11, November 2016, pp. 4039–4047.

[3] M. Asefi, A. Zakaria, and J. LoVetri, "Microwave imaging using normal electric-field components inside metallic resonant chambers," *IEEE Trans. Microw. Theory Techn.*, **65**, no. 3, March 2017, pp. 923–933.

[4] K. Nemez, M. Asefi, A. Baran and J. LoVetri "A faceted magnetic field probe resonant chamber for 3D MWI: A synthetic study," *ANTEM, 17th Int, Symp. on Ant. Tech. and Applied Electromagnetics*, July 2016.

[5] N. Abdollahi, I. Jeffrey and J. LoVetri "Green's theorem based eigenfunction formulations for PEC-enclosed electromagnetic imaging," *ANTEM, 17th Int, Symp. on Ant. Tech. and Applied Electromagnetics*, July 2016.

[6] N. Abdollahi, I. Jeffrey and J. LoVetri "A non-iterative eigenfunction-based inverse solver for PEC-enclosed electromagnetic imaging," *XXXIInd URSI GASS, General Assembly and Scientific Symposium*, August 2017.

[7] I. Jeffrey, N. Geddert, K. Brown, and J. LoVetri, "The time-harmonic Discontinuous Galerkin Method as a robust forward solver for microwave imaging applications," *Progress In Electromagnetics Research*, **154**, 2015, pp. 1–21.