A Non-Iterative Eigenfunction-Based Inverse Solver for PEC-Enclosed Electromagnetic Imaging

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1 Extended Abstract

For nearly a decade researchers have been interested in electomagnetic imaging within PEC-bounded enclosures [1]-[4], either out of necessity [3], for simplified modelling [4], or to investigate advantages over open-field configurations [1, 2, 4]. Within PEC enclosures, eigenfunctions provide a natural basis for electomagnetic fields and can also be used to expand unknown contrast or contrast source profiles, as previously demonstrated in a 2D TM iterative contrast source inversion (CSI) algorithm for the reconstruction of complex dielectric targets in circular systems [2]. This method made use of an underlying pixel-based descretization of the imaging domain to evaluate the required norms. More recently, we have been investigating semi-analytic, mesh-free eigenfunction formulations [5] for electromagnetic inversion within PEC enclosures, focusing on mechanisms by which to constrain the class of recoverable contrast sources through appropriately selected measurements, Green's theorem based constraints, and prior knowledge of contrast source locality.

In this work, we present a unique non-iterative scheme for direct recovery of contrast sources via a constrained eigenfunction-basis 2D TM inverse source problem. This approach exploits the one-to-one correspondence between contrast source coefficients and scattered field coefficients within the appropriate eigenfunction basis. This essentially converts the inverse source problem to a global scattered-field recovery problem. The fact that contrast sources are zero outside the imaging domain imposes constraints on the corresponding field coefficients and provides regularization. Combining the solutions for a set of interrogating transmitters allows for the contrast profile to be recovered directly in the least-square sense, an approach common to other inversion techniques such as CSI. This formulation has been tested on synthetic data for a variety of simple low-contrast targets, as well as for high-contrast synthetic biological targets. To deal with the practical design of such imaging systems, synthetic data is taken as tangential magnetic field measurements over the enclosure boundary. As will be shown, results are promising as they compare well with, and at times out-perform, a DGM-CSI algorithm [6].

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] P. Mojabi, and J. LoVetri, "Eigenfunction contrast source inversion for circular metallic enclosures," *Inverse Problems* , **26**, 2, January 2010.

[3] M. Asefi *et. al.*, "Grain bin monitoring via electromagnetic imaging," *Computers and Electronics in Agriculture*, **119**, November 2015, pp. 113–141.

[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 International Symposium on Antenna Technology 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 International Symposium on Antenna Technology and Applied Electromagnetics*, July 2016.

[6] I. Jeffrey, A. Zakaria, and J. LoVetri "Microwave imaging by mixed-order discontinuous Galerkin contrast source inversion," *URSI GASS, General Assembly and Scientific Symposium* , XXXIth URSI, August 2014, pp. 1–4.