A Projected Steepest Descent Accelerated Contrast-Source Inversion Scheme for Nonlinear Electromagnetic Imaging

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Developing efficient and accurate numerical schemes for solving the electromagnetic (EM) inverse scattering problem on spatially-sparse investigation domains has become an active research topic over the past few years. This is simply because such sparse domains naturally exist in many applications including non-destructive testing, crack detection, and see-through wall imaging. Indeed, recently, sparsity-constrained regularization schemes have been successfully developed for nonlinear EM imaging. These algorithms use L_0/L_1-norm of the solution as the penalty term in the nonlinear minimization problem required by the inversion process. Two examples are a preconditioned in-exact Newton contrast-source (INCS) scheme in (A. Desmal and H. Bagci, *IEEE Trans. Geosci. Remote Sens.* 12, 532-536, 2015) and a scheme making use of nonlinear Landweber (NLW) iterations in (A. Desmal and H. Bagci, *Progress In Electromagnetics Research*, 152, 77-93, 2015). Numerical results presented in these papers have demonstrated that sparsity (L_0/L_1-norm) -constrained INCS scheme and NLW iterations produce sharper and more accurate reconstructions than "traditional" inversion schemes making use of L_2-norm-constrained regularization. However there is room for improvement when it comes to the application of these sparsity-constrained schemes in practical problems. One issue that needs to be addressed is the slow convergence, which might become prohibitive when the investigation domain is electrically large.

In this work, an accelerated inversion algorithm is developed for nonlinear EM imaging of two-dimensional spatially-sparse investigation domains. Like the INCS scheme, it uses the contrast-source (CS) formulation since it allows both contrast and source samples to be sparse at the same time (as opposed to contrast-field formulation where field samples are not immediately sparse). However, to avoid generating a sequence of linear sparse optimization problems, the nonlinearity is directly tackled using the NLW iterations. The efficiency of the NLW iterations is significantly increased using an accelerated projected steepest descent (PASD) algorithm which projects the result of each steepest descent iteration into the unit ball to enforce the sparsity constraint and selects the largest possible iteration step without sacrificing from convergence.

Numerical results, which demonstrate the proposed scheme's accuracy, efficiency, and applicability, will be presented.