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Multi-Focusing Procedure based on the Inexact-Newton Method for Electromagnetic Subsurface Prospecting

Marco Salucci (1), Giacomo Oliveri (1), Andrea Massa (1), Andrea Randazzo (2), and Matteo Pastorino (2)

(1) ELEDIA Research Center, Department of Information Engineering and Computer Science, University of Trento, Trento, Italy ({marco.salucci; giacomo.oliveri}@disi.unitn.it, andrea.massa@ing.unitn.it), (2) Applied Electromagnetics Group, Department of Electrical, Electronic, Telecommunications Engineering, and Naval Architecture, University of Genoa, Genoa, Italy ({andrea.randazzo; matteo.pastorino}@unige.it)

Ground penetrating radars (GPRs) are key instruments for subsurface monitoring and imaging. They can be used in different applicative fields, e.g., for the assessment of the structural stability of concrete structures and for the detection of targets buried inside inaccessible materials. In this framework, imaging systems based on the solution of the underlying inverse electromagnetic scattering problem have been acquiring an ever growing interest in the scientific community. In fact, they are able – at least in principle – to provide a quantitative reconstruction of the distributions of the dielectric properties (e.g., the dielectric permittivity and the electric conductivity) of the investigated scenario. Although good results have been obtained in recent years, there is still the need of further research, especially concerning the development of inversion procedure able to deal with the limitations arising from the non-linearity and ill-posedness of the underlying electromagnetic imaging formulation.
In this work, a novel electromagnetic inverse scattering method is proposed for the reconstruction of shallow buried objects. The inversion procedure is based on the combination of different imaging modalities. In particular, an iterative multi-scaling approach [1] is adopted for focusing the reconstruction only on limited subdomains of the original investigation region. The data inversion is performed by applying an inexact-Newton method (which exhibits very good regularization properties) within the second-order Born approximation [2]. The use of this approximation allows a reduction of the problem unknowns and a mitigation of the nonlinear effects. The proposed approach has been validated by means of several numerical simulations. In particular, the reconstruction performances have been evaluated in terms of accuracy, robustness, noise levels, and computational efficiency, with particular emphasis on the comparisons with the results obtained by using the standard “bare” approach.

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