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Qualitative Microwave Subsurface Imaging by means of a Multi-Resolution Multi-Region Level Set method

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Subsurface sensing is a wide branch of non-invasive diagnostic concerned with the detection of unexploded ordnance as well as oilfield discovery. In this framework, many approaches have been proposed by considering different probing techniques as for instance x-rays, ultrasonics, eddy currents, and microwaves. As far as microwaves are concerned, such techniques have been recently recognized as suitable and effective tools [1]. Within microwave methodologies, inverse scattering approaches are aimed at retrieving a complete image of the region under test. Unfortunately, the underlying mathematical model is intrinsically ill-posed as well as non-linear. In order to cope with the ill-posedness, multi-view and multi-illumination systems are generally used to collect a sufficient amount of independent data. However, the amount of independent data is an upper-bounded quantity [2]. Therefore, the number of unknowns cannot be very large. Consequently, in order to achieve satisfactory reconstructions with a suffcient spatial accuracy without the presence of local minima, multi-resolution approaches have been proposed [3]. Besides multi-resolution techniques, another method for counteracting the lack of information lies in the exploitation of the available a-priori knowledge. In subsurface sensing, the scenario under test might often be represented by a binary contrast where the electromagnetic properties of both the target and the host-medium are known quantities. Under these assumptions, the imaging problem reduces to the search of position and shape of the scatterer lying in the host medium and optimization methods such as Level Set can be profitably employed [4]. In order to exploit both the available a-priori information and independent data from scattering measurements, this paper proposes an innovative approach based on a multi-resolution multi-region Level Set aimed at dealing with complex scenarios characterized by the presence of more-than-one target. Such a technique is based on a multi-step procedure aimed at increasing the spatial resolution inside limited regions of interest where the scatterers are more carefully localized. Moreover, only the shapes of the objects are iteratively estimated by means of a multi-regions Level Set procedure. The proposed approach is assessed by means of a selected set of results and compared with the single-resolution as well as the multi-resolution single-region approaches in order to point out potentialities and current limitations.

REFERENCES

1. R. Zoughi, Microwave Nondestructive Testing and Evaluation. Dordrecht, The Netherlands: Kluwer Academics Publishers, 2000.
2. O. M. Bucci and T. Isernia, "Electromagnetic inverse scattering: retrievable informations and measurement strategies," Radio Science, vol. 32, pp. 2123-2138, 1997.
3. S. Caorsi, M. Donelli, and A. Massa, "Detection, location, and imaging of multiple scatterers by means of the iterative multiscaling method," IEEE Trans. Microwave Theory Tech., vol. 52, no. 4, pp. 1217-1228, 2004.
4. O. Dorn and D. Lesselier, "Level set methods for inverse scattering," Inverse Problems, vol. 22, pp. R67-R131, 2006.