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Dealing with Aspect-Limited Data through an Innovative Microwave Imaging Multi-Source Technique - Potentialities and Limitations

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Whatever application, a microwave imaging setup consists of a probing source that senses an inaccessible investigation domain and a set of receivers collecting samples of the electromagnetic field scattered by the structure under test. After the measurement phase, a post-processing of the collected data is performed to provide a faithful reconstruction of the scenario under test. Such a retrieval process presents some intrinsic drawbacks, which make the inversion of the scattering data hard to cope with. Firstly, wheter a complete and quantitative reconstruction of the electromagnetic properties is needed, multiple scattering effects cannot be neglected and a full non-linear model should be considered. Moreover, the ill-posedness and the ill-conditioning of the problem are key-issues to be carefully addressed. They are due to the lack of information coming from measured scattering data further reduced because of mechanical constraints in the measurement setup that generally allows a collection of a set of aspect-limited field samples. During the imaging process, a huge amount of parameters has to be retrieved starting from a limited number of independent measurements. Thus, if neither a-priori information are available nor other physical constraints are imposed, there is the need to collect other information by means of suitable techniques. Within such a framework, different strategies aimed at increasing the information content of scattering data have been proposed. Let us consider the multi-view strategy proposed in [*Caorsi et al.*, 1991] where the scatterer is illuminated from different angular directions in order to give an "overview" of the scenario under test. As determined in [*Bucci and Isernia*, 1997], such a technique allows a significant increasing of independent scattering data with respect to single-view experiments. However, even though a multiview method can partly add information, it cannot fully overcome the substantial lack of information. Another widely-used countermeasure resorts to a multi-frequency approach [*Belkebir et al.*, 1997]. As far as the collectable information is concerned, the number of independent data certainly increases since different and complementary scattering effects are excited by a set of incident electromagnetic fields at different frequencies. However, to fully exploit such an enhancement of the knowledge of the scenario, some a-priori assumptions have to be done about the dispersion model of the dielectric characteristics of the scatterer [*Bucci et al.*, 2000].

In this contribution, an innovative methodology aimed at increasing the amount of scattering data (avoiding further a-priori assumptions on the investigation domain) is analyzed. According to the multi-source (MS) approach, the investigation domain is illuminated by means of different probing sources, each of them characterized by a proper (and different) radiation pattern, to induce different scattering interactions able to "show" different "aspects" of the scatterer under test. Integrated with a multi-view strategy and recurring to the iterative multi-scaling procedure [*Donelli et al.*, 2006], the exploitation of the "source diversity" (through the definition of a suitable multi-source/multi-view cost function) enlarges in a non-negligible fashion the number of retrievable unknowns by enhancing the robustness of the imaging process with respect to the noise and the stability of the inversion procedure as well as the reconstruction accuracy. Moreover, the reduction of the ratio between dimension of the space of the unknowns and that of data implies a decreased sensitivity to false solutions [*Isernia et al.*, 2001] leading to a more tractable optimization problem. A large number of numerical simulations confirm the effectiveness of the inversion strategy as well as its robustness with respect to noise on data. Moreover, the results of a comparative study with single-source methodologies further point out the advantages and potentialities of the approach when dealing with aspect-limited data acquisition setups.

References

Belkebir, K., R. Kleinman, and C. Pichot (1997), Microwave imaging - Location and shape reconstruction from multifrequency scattering data, IEEE Trans. Microwave Theory Tech., 45, 469-475.

Bucci, O.M., and T. Isernia (1997), Electromagnetic inverse scattering: retrievable information and measurements strategies, Radio Science, 2123-2138.

Bucci, O. M., L. Crocco, T. Isernia, and V. Pascazio (2000), Inverse Scattering Problems with Multifrequency Data: Reconstruction Capabilities and Solution Strategies, IEEE Trans. Geosci. Remote Sensing, 38, 1749-1756.

Caorsi, S., G. L. Gragnani, and M. Pastorino (1991), An approach to microwave imaging using a multiview moment method solution for a two-dimensional infinite cylinder, IEEE Trans. Microwave Theory Tech., 39, 1062-1067.

Donelli, M., G. Franceschini, A. Martini, and A. Massa (2006), An integrated multi-scaling strategy based on a particle swarm algorithm for inverse scattering problems, IEEE Trans. Geosci. Remote Sensing, 44, 298-312.

Isernia, T., V. Pascazio, R. Pierri (2001), On the Local Minima in a Tomographic Imaging Technique, IEEE Trans. Geosci. Remote Sensing, 39, 1596-1607.