Inversion of Large-scale Electromagnetic Data through the Iterative Multizooming Reconstruction of Nonmeasurable Equivalent Current Densities

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In the framework of the inversion of electromagnetic data, several methodologies consider the introduction of an equivalent current density defined into the dielectric domain to be reconstructed. One of the main drawbacks of these approaches is their "difficulty" to reconstruct the so-called "nonradiating" (or "nonmeasurable") components of the equivalent current density. Hence the obtained solution may suffer from a strong low-pass effect. In order to overcome this drawback, *Habashy et al.*, [1] presented a reconstruction method where the problem of nonmeasurable currents was addressed through a successive steps process. Taking into account the guidelines suggested in [1], *Gragnani et al.*, [2] proposed a nonlinear procedure based on the reconstruction of the measurable components of the equivalent current density by means of the singular value decomposition of the discretized Green's operator. Such components are then inserted into a nonlinear equation whose unknowns are the nonmeasurable components as well as the dielectric properties of the investigation domain. Then, a nonlinear functional is defined and minimized by means of a standard steepest-descent procedure.

Even though the results obtained by taking into account the nonmeasurable current density were better than the ones of the minimum-norm solution, the method demonstrated some inaccuracies or faults due to the presence of the local minima. Moreover, the choice of a suitable representation for the nonradiating currents represented an open problem partially addressed.

In this paper, these problems are faced through an integrated strategy based on an innovative stochastic method and on an iterative multizooming procedure. Since the existence of nonradiating components is equivalent to the Green's integral operator having a null-space and one way to decrease the size of the null space is to let the equivalent current density have fewer degrees of freedom, it is convenient to approximate this density with a smaller number of basis or unknowns, e.g., by using a coarse grid in the domain under test [3]. Consequently, the reconstructed profile presents a poor spatial resolution because of the inappropriate sampling step. Therefore, an iterative multizooming process is considered. Starting from a coarse representation, the method iteratively defines a subgridding of the support of the equivalent current density successively improving the representation of the current by minimizing the nonlinear cost function defined in [2]. In order to avoid local minima problems, an innovative minimization technique based on the particle swarm optimizer (PSO) [4] is used.

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