The Kernel Method for Electrical Resistance Tomography

Antonello Tamburrino[1], Vincenzo Mottola[1]

[1]Dipartimento di Ingegneria Elettrica e dell'Informazione "M. Scarano", Università degli Studi di Cassino e del Lazio Meridionale, Italy

In this paper we deal with Electromagnetic Tomography with low-frequency excitation, that is a case of Soft-Field Tomography. Imaging problems related to Soft-Field Tomography are of great interest since these techniques share some unique properties such as the absence of ionizing radiations, low-cost operations, and the availability of real-time inversion methods. On the other hand, such kind of problems are quite difficult to handle since they are nonlinear and ill-posed. There are several examples of Soft-Field Tomography techniques such as: Electrical Resistance Tomography, Electrical Capacitance Tomography and Magnetic Induction Tomography. Unlike Computed Tomography, for example, where the electromagnetic field path is a priori known, here the electromagnetic field path depends on the spatial behaviour of the unknown material property. This determines a reduction in the spatial resolution and the nonlinearity of the problem. In literature it is possible to find two different families of approaches. The first one, rather well established, comprises iterative methods, in which the aim is to iteratively minimize a proper cost functional related to the discrepancy between measured data and simulated ones, and a priori information. The main drawback consists in the huge number of required iterations, because of the intrinsic ill-posedness of the problem. Moreover, at each step at least one numerical solution of the forward problem is needed, thus making this approach not suitable for real-time imaging. A second family consists of non-iterative methods. In this case, starting from the analysis of the physical and mathematical properties of the problem, a proper indicator function is introduced to achieve real-time performances. Only few methods of this family are available in literature such as: the Monotonicity Principle Method, the Enclosure Method, the Factorization Method, MUSIC. In this paper, we introduce a new non-iterative inversion method in the field of Electrical Resistance Tomography, where the goal is to determine the spatial behaviour of the unknown electrical conductivity, starting from boundary measurements (DC voltages or currents). Specifically, we deal with the inverse obstacle problem whose aim is to reconstruct an unknown anomaly in a given background material. The foundation of the method is given by the possibility of finding, starting from boundary measurements, an optimal excitation, i.e. such that the electrical current density is vanishing in the region occupied by the anomaly on a reference configuration (background only). Starting from this property, we develop a new non-iterative inversion method, which allows to carry out reconstructions with the evaluation of only one direct problem. The method has a very simple and stable implementation, with a very low-computational cost and, hence, suitable for real-time applications.