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Microwave Imaging Method Developed in Lebesgue Spaces for Inspecting Dielectric Targets

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As it is well known, the realization of imaging systems working at microwave frequencies requires the effective solution of the electromagnetic inverse scattering problem [1]. The research in this area is ever expanding and new procedures are continuously reported. Beside qualitative methods, in which approximations are used, tomography usually requires the use of exact approaches, i.e., aimed at solving the equations of the inverse scattering problem without approximations different from those related to the numerical procedure adopted to discretize them. In the past years, several different methods have been applied. Gauss-Newton methods seem very effective in this framework (see, for example, [2], [3]).

The present authors proposed in [4] an approach working in the framework of the L^p Banach spaces with constant exponent p. The main difficulty connected to this approach is the need for the choice of a fixed p parameter, which determines the norm of the space in which the solution is searched. Actually, it has been found that the reconstruction quality strongly depends on the choice of this parameter. In the present paper, we discuss a procedure that overcomes the need for an a-priori selection of the above parameter. This formulation makes use of new concepts related to the variable exponent $L^{p(\cdot)}$ Lebesgue spaces. In particular, the p parameter can assume different values in different parts of the inspected region. In this way, it is possible to reconstruct dielectric targets in a given investigation region exploiting the features associated to different values of p. For example, small values of p have been found to improve the reconstructions of void parts of the investigation area, while higher values are more suited to produce images of the dielectric scatterers with a reduced over-smoothing effects.

In this paper, this approach, which has been preliminary discussed in [5], is also extended by evaluating different mapping functions for defining the distribution of the p values inside the investigation domain in each Gauss-Newton iteration. In addition, several numerical results are reported and discussed, with reference to a tomographic imaging approach (i.e., cylindrical dielectric targets under transverse magnetic illumination conditions). Finally, some preliminary experimental results are reported and discussed.

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