Microwave Imaging in Stratified Media by Means of a Finite-Element Variable-Exponent Inversion Approach

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Stratified media can be found in numerous applicative fields ranging from subsurface prospection (e.g., soil mapping and road pavement monitoring) to industrial non-destructive testing [1], [2]. In this framework, microwave imaging appears as a promising diagnostic technique. This is mainly due to the capability of this class of techniques to perform a non-invasive inspection and characterization of the structures under test [3].

In order to retrieve the full distributions of the dielectric properties of the investigated region, various kinds of quantitative inverse-scattering techniques have been developed to tackle the ill-posedness and nonlinearity of the underlying inverse problem [4], [5]. Among them, promising results have been achieved by non-Hilbertian methods formulated in variable-exponent Lebesgue spaces and based on outer-inner inexact Newton schemes [6]. These regularization procedures, different from fixed-exponent Lebesgue-space techniques, do not require to choose an optimal fixed value of the exponent because a variable exponent function is introduced, which is properly tuned iteration after iteration.

In this contribution, a nonlinear microwave inverse scattering procedure formulated in variable-exponent $L^{p(\cdot)}$ spaces, combined with a finite-element (FE) modelling of the electromagnetic problem, is applied to the imaging of stratified media. Thanks to the FE-based approach, an accurate description of the measurement setup is obtained, under a two-dimensional approximation. The model includes the S-parameters response at antenna ports and perfectly matched anisotropic absorbing layers are enforced at boundaries.

The performance of the proposed quantitative inverse scattering method has been validated in a numerically simulated scenario, where stratified media illuminated by open waveguide antennas are present.

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