Quantitative Imaging of Targets Embedded in a Layered Environment by a VLS-FE Nonlinear Inversion Method

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Microwave imaging techniques represent relevant methods for a non-destructive detection of targets in many applicative scenarios characterized by layered environments, such as in civil engineering, geophysics and archeology [1, 2]. In particular, quantitative inverse-scattering techniques allow the full characterization of the investigated scenario by retrieving the distribution of its dielectric properties but require a suitable inverse procedure able to face the underlying ill-posed and nonlinear scattering problem.

In this respect, a promising class of inversion approaches is represented by techniques in Variable-exponent Lebesgue Spaces (VLS), which are able to mitigate some of the most relevant limitations of standard Hilbert-space methods (e.g., over-smoothing and ringing effects) and fixed-exponent Lebesgue-space approaches (e.g., the need of setting a fixed norm parameter) [3, 4].

In order to achieve accurate quantitative imaging of targets in layered environments, a VLS technique combined with a Finite-Element (FE) modeling of the scattering scenario is considered in this work. The VLS-FE method exploits an S-parameter data equation [5] to relate the data measured at antenna ports to the contrast function inside the investigation domain in a two-dimensional setting. Inversion is done by adopting a two-loop inexact-Newton scheme, where the problem is iteratively linearized (external loop) and then solved by a regularizing VLS Landweber-like technique.

A numerical analysis concerning the reconstruction of dielectric targets is performed to validate the method in different operating conditions and to assess the behavior of the VLS-FE approach versus changes in its most relevant parameters.

References

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