A Regularization Approach in Lebesgue Spaces for Antenna Array Diagnostics

Valentina Schenone(1), Alessandro Fedeli(1), Claudio Estatico(2), Matteo Pastorino(1), and Andrea Randazzo*(1)
(1) Department of Electrical, Electronic, Telecommunications Engineering, and Naval Architecture, University of Genoa, Genoa, Italy.
(2) Department of Mathematics, University of Genoa, Genoa, Italy.

Mathematical methods represent very important tools in computational electromagnetics. Consequently, in the last years, novel techniques have been continuously proposed in several areas, such as for the solution of forward problems [1], for inverse-scattering applications [2], and for antenna design and optimization [3]. In this framework, an important field where numerical techniques play a fundamental role is antenna diagnostics. Indeed, in most cases, it is necessary to solve an inverse problem in order to retrieve the distributions of the current over the antenna (or of the excitations coefficients when dealing with antenna arrays) starting from measurements of the radiated field [4]. Such an inverse problem turns out to be ill-posed (and non-linear, if amplitude-only measurements are available). Consequently, proper regularization techniques are needed.

In this contribution, an inversion technique for antenna array diagnostics, relying on the adoption of a regularization scheme developed in Lebesgue spaces [5], is presented. One of the main advantages of such an approach is related to the possibility of tuning the norm exponent to the specific problem at hand. In particular, low values close to 1 are better suited for retrieving sparse solution, e.g., in the case of isolated faulty elements of the array. On the contrary, higher values close to 2 (which corresponds to standard Hilbert-space regularization techniques) allow a suitable retrieval of clustered fault distributions, for which other approaches relying on sparsity (e.g., the compressive sensing ones) may provide solutions not enough accurate.

The developed approach is tested by considering different types of simulated planar arrays, in order to assess its performance versus some relevant parameters.

This work was supported in part by the Italian Ministry for Education, University, and Research through the Project PRIN2017 DI-CA under Grant 20177C3WRM

References

[1] A. Samokhin, Y. Shestopalov, and K. Kobayashi, “Stationary iteration methods for solving 3D electromagnetic scattering problems,” *Applied Mathematics and Computation*, **222**, October 2013, pp. 107–122, doi: 10.1016/j.amc.2013.07.019.

[2] M. T. Bevacqua and T. Isernia, “Quantitative non-linear inverse scattering: A wealth of possibilities through smart rewritings of the basic equations,” *IEEE Open Journal of Antennas and Propagation*, **2**, 2021, pp. 335–348, doi: 10.1109/OJAP.2021.3063248.

[3] S. C. Pavone, A. Mazzinghi, and M. Albani, “PO-based automatic design and optimization of a millimeter-wave sectoral beam shaped reflector,” *IEEE Transactions on Antennas and Propagation*, **68**, 6, June 2020, pp. 4229–4237, doi: 10.1109/TAP.2020.2971523.

[4] M. Salucci, A. Gelmini, G. Oliveri, and A. Massa, “Planar array diagnosis by means of an advanced Bayesian compressive processing,” *IEEE Transactions on Antennas and Propagation*, **66**, 11, November 2018, pp. 5892–5906, doi: 10.1109/TAP.2018.2866534.

[5] V. Schenone, A. Fedeli, C. Estatico, M. Pastorino, and A. Randazzo, “Detection of failures in antenna arrays through a Lebesgue-space approach,” *IEEE Open Journal of Antennas and Propagation*, **3**, 2022, pp. 652–662, doi: 10.1109/OJAP.2022.3181345.