SET-192 Specialist Meeting on "Compressed Sensing for Radar/SAR"

Bayesian Compressive Sensing for Radar Systems and Applications - Recent Advances at the ELEDIA Research Center

Giacomo Oliveri, Paolo Rocca, and Andrea Massa

ELEDIA Research Center@Department of Information Engineering and Computer Science
University of Trento, Via Sommarive 5, I-38123 Trento, Italy.
Phone: +390461282957. Fax: +390461283166. E-mail: andrea.massa@ing.unitn.it
Web-page: http://www.eledia.ing.unitn.it

Abstract

In the recent years, the Compressive Sensing paradigm [1] has emerged in the field of Electromagnetics (EM) as one of the most interesting and powerful set of approaches for effectively addressing sparsely-formulated problems arising in several applicative areas, including array design, antenna diagnosis, direction-of-arrival (DoA) estimation, and remote sensing [2]-[11]. Indeed, CS retrieval algorithms have demonstrated a significant advantage over state-of-the-art methodologies in terms of accuracy, speed, robustness to noise, and flexibility whenever the problem of interest can be formulated as (*a*) linear and (*b*) sparse with respect to its unknowns [1]-[11]. Unfortunately, their use in EM applicative scenarios and specifically Radar System design must be carefully addressed both from the practical and from the theoretical viewpoint. As a matter of fact, common assumptions that guarantee the convergence of widely adopted l_1-based solvers, such as the Restricted Isometry property, cannot be easily verified in most EM problems, contrary to what happens in traditional signal processing applications of CS. Accordingly, suitable re-formulations of the problems, often within a probabilistic framework, and solution strategies (e.g., belonging to the "Bayesian CS" [*BCS*] category) can be adopted in order to properly address design/inversion problems arising in Radar Systems and Applications.

Within such a framework, this contribution will be aimed at reviewing some recent advances carried out at the ELEDIA Research Center in the field of BCS as applied to the solution of state-of-the-art Radar System problems, as well as at providing some useful hints for the exploitation of such techniques in emerging Radar Applications. Such a review will contribute to the Meeting by illustrating the applicative scenarios in which CS techniques, and specifically their Bayesian formulation, can be effectively used and what are the advantages and drawbacks of such stochastic CS approaches with respect to traditional compressive sensing retrieval algorithms in terms of acquired information, flexibility, and range of applicability. The contribution will also include the discussion of recent industrial applications developed in the ELEDIA Research Center of the BCS strategies in the framework of Radar System, and will envisage some potential future applicative area of these techniques.

References

[1] E. J. Candes and M. B. Wakin, "An introduction to compressive sampling," *IEEE Signal Process. Mag.*, vol. 25, no. 2, pp. 21-30, March 2008.

[2] G. Oliveri and A. Massa, "Bayesian compressive sampling for pattern synthesis with maximally sparse non-uniform linear arrays," *IEEE Trans. Antennas Propag.*, vol. 59, no. 2, pp. 467-481, Feb. 2011.

[3] G. Oliveri, P. Rocca, and A. Massa, "A Bayesian compressive sampling-based inversion for imaging sparse scatterers," *IEEE Trans. Geosci. Remote Sens.,* vol. 49, no. 10, part 2, pp. 3993-4006, Oct. 2011.

[4] G. Oliveri, M. Carlin, and A. Massa, "Complex-weight sparse linear array synthesis by Bayesian Compressive Sampling," *IEEE Trans. Antennas Propag.*, vol. 60, no. 5, pp. 2309-2326, May 2012.

[5] L. Poli, G. Oliveri, and A. Massa "Microwave imaging within the first-order Born approximation by means of the contrast-field Bayesian compressive sensing", *IEEE Trans. Antennas Propag.*, vol. 60, no. 6, pp. 2865-2879, June 2012.

[6] G. Oliveri, L. Poli, P. Rocca, and A. Massa, "Bayesian compressive optical imaging within the Rytov approximation", *Opt. Lett.*, vol. 37, no. 10, pp. 1760-1762, 2012.

[7] G. Oliveri, P. Rocca, and A. Massa "Reliable diagnosis of large linear arrays - a Bayesian Compressive Sensing approach", *IEEE Trans. Antennas Propag.*, vol. 60, no. 10, pp. 4627-4636, Oct. 2012.

[8] L. Poli, G. Oliveri, P. Rocca, and A. Massa, "Bayesian Compressive Sensing approaches for the reconstruction of two-dimensional sparse scatterers under TE illuminations", *IEEE Trans. Geosci. Remote Sens*., vol. 51, no. 5, pp. 2920-2936, May 2013.

[9] F. Viani, L. Poli, G. Oliveri, F. Robol, and A. Massa, "Sparse scatterers imaging through approximated multi-task compressive sensing strategies," *Microwave Opt. Technology Lett.*, vol. 55, no. 7, pp. 1553-1558., Jul. 2013.

[10] M. Carlin, P. Rocca, G. Oliveri, F. Viani, and A. Massa, "Directions-of-arrival estimation through Bayesian Compressive Sensing strategies," *IEEE Trans. Antennas Propag.*, in press. doi:10.1109/TAP.2013.2256093

[11] L. Poli, G. Oliveri, and A. Massa, "Imaging sparse metallic cylinders through a local shape function Bayesian Compressive Sensing approach," *Journal of Optical Society of America A*, in press.