

Thursday November 21st, 2013 @ 3:00 p.m.
SUPELEC - Gif-sur-Yvette, France

Compressive Sensing as applied to Electromagnetics

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Abstract

The widely known Shannon/Nyquist theorem relates the number of samples required to reliably retrieve a “signal” to its (spatial and temporal) bandwidth. Such a fundamental criterion yields to both theoretical and experimental constraints in several applications in the fields of inverse scattering, antenna synthesis and measurements, as well as adaptive array control. Indeed, there is a relation between the number of measurements/data (complexity of the acquisition/processing), the degrees of freedom of the field/signal (temporal/spatial bandwidth), and the retrievable information regarding the phenomena at hand (e.g., dielectric features of an unknown object, presence/position of damages in an array, location of an unknown incoming signal).

The new paradigm of Compressive Sensing (CS) is enabling an overall revision of such concepts by distinguishing the “informative content” of signals from their bandwidth. Indeed, CS theory asserts that one can recover certain signal/phenomena exactly from far fewer measurements than it is indicated by Nyquist sampling rate. To achieve this performance, CS relies on the sparsity/compressibility of the signal at hand, i.e, on the fact that most natural phenomena can be represented by few non-zero coefficients in suitable expansion bases, and on the use of aperiodic sampling strategies, which can guarantee, under suitable conditions a perfect recovery of the information content of the signal. Some interesting results have already been obtained by exploiting CS techniques to solve problems in non-uniform array design and analysis, microwave imaging of sparse scatterers, array diagnosis, and direction-of-arrival estimation.

The aim of this talk is to discuss CS starting from some its fundamentals and to exploit its features in different applicative fields concerned with Electromagnetics. More specifically, recent advances in the application of CS to inverse scattering & imaging methods for NDE/NDT, array synthesis, DoA CS-based approaches, and antenna diagnosis will be presented, envisaging possible future trends in CS as applied to Electromagnetics.

Andrea Massa received the “laurea” degree in Electronic Engineering from the University of Genoa, Genoa, Italy, in 1992 and Ph.D. degree in EECS from the same university in 1996. From 1997 to 1999, he was an Assistant Professor of Electromagnetic Fields at the Department of Biophysical and Electronic Engineering (University of Genoa). From 2001 to 2004, he was an Associate Professor at the University of Trento. Since 2005, he has been a Full Professor of Electromagnetic Fields at the University of Trento, where he currently teaches electromagnetic fields, inverse scattering techniques, antennas and wireless communications, wireless services

and devices, and optimization techniques. At present, Prof. Massa is the director of the ELEDIA Research Center at the University of Trento with a staff of more than 25 researchers. Moreover, he is Adjunct Professor at Penn State University (USA) and he has been Visiting Professor at the Missouri University of Science and Technology (USA), at the Nagasaki University (Japan), at the University of Paris Sud (France), at the Kumamoto University (Japan), and at the DigiTEo (Paris – France).

Prof. Massa serves as Associate Editor of the “IEEE Transaction on Antennas and Propagation” and Associate Editor of the “International Journal of Microwave and Wireless Technologies” and he is member of the Editorial Board of the “Journal of Electromagnetic Waves and Applications”, and a permanent member of the “PIERS Technical Committee” and of the “EuMW Technical Committee”. He has been appointed in the Scientific Board of the “Società Italiana di Elettromagnetismo (SIEm)” and elected in the Scientific Board of the Interuniversity National Center for Telecommunications (CNIT). Recently Prof. Massa has been appointed by the National Agency for the Evaluation of the University System and National Research (ANVUR) as a member of the Recognized Expert Evaluation Group (Area 09, ‘Industrial and Information Engineering’) for the evaluation of the researches at the Italian University and Research Center in the period 2004-2010. Moreover, he has been appointed as the Italian Member of the Management Committee of the COST Action TU1208 “Civil Engineering Applications of Ground Penetrating Radar”.

His research activities are mainly concerned with direct and inverse scattering problems, propagation in complex and random media, analysis/synthesis of antenna systems and large arrays, design/applications of WSNs, cross-layer optimization and planning of wireless/RF systems, semantic wireless technologies, material-by-design (metamaterials and reconfigurable-materials), and theory/applications of optimization techniques to engineering problems (telecommunications, medicine, and biology).

Prof. Massa published more than 500 scientific publications among which about 250 on international journals and more than 270 in international conferences where he presented more than 50 invited contributions. He has organized 45 scientific sessions in international conferences and has participated to several technological projects in the European framework (10 EU Projects) as well as at the national and local level with national agencies (40 Projects/Grants).

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