A CS-based approach for physical imaging

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Imaging algorithms able to address the intrinsic challenges of inverse problems represent an important research topic in several applicative scenarios including biomedical diagnostics, non-destructive testing, and subsurface prospecting. In order to address such theoretical issues, the exploitation of regularized formulations has been widely considered in the literature.

In this framework, the Compressive Sensing (CS) has emerged as one of the most powerful paradigms to develop robust and efficient inversion methodologies for microwave and optical imaging. CS techniques can be exploited whenever (i) the data y (e.g., the scattered field) are linearly related to the unknowns x (e.g., the equivalent sources or the contrast), so that the data equation can be written as y=Ax, and (ii) these unknowns have a (direct or indirect) sparse representation in a suitable basis. The first attempts to exploit CS methods to time-harmonic microwave imaging problems have included the retrieval of “pixel-shaped” scatterers in 2D transverse-magnetic (TM) or transverse-electric (TE) contrast-source formulations, also comprising hybridizations with minimum-norm techniques. Approximated formulations have been considered as well, and the retrieval of metallic targets has been addressed by local-shape-function techniques. Such approaches, based on Bayesian Compressive Sensing solvers, have been then extended more recently to handle “non-pixel-shaped” scatterers. In this latter case, however, deterministic CS total-variation techniques have been considered in order to suitably solve the arising inverse problems.

Within this scenario, this work is aimed at presenting a set of innovative methodologies developed in CS imaging able to exploit a-priori knowledge on the nature and physics of the electromagnetic problem (i.e., field behavior) or of the scatterer at hand (i.e., class of objects) in order to perform the most proper choice of the expansion basis. Numerical comparisons with state-of-the-art approaches will be provided to remark the potentialities and limitations of the arising Physical CS Imaging approaches.