On Elimination of Ill-posedness in the Inverse Problem via Separation of Partial Scattered Field Using New Antenna Array Concept

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In the conventional approaches for the solution of the inverse problem, the total field produced by the imaged object are collected at a set of arbitrary observation points external to it. Such a way of formulating the inverse problem is inherently ill-posed. Normally, this ill-posedness is eliminated mathematically through Tikhonov regularization which violates physical equation governing the electromagnetic fields. In this work we developed a new physics based regularization approach which preserves the rigour in the statement of the Lippman-Schwinger integral equation. This is achieved by spatial separation of the scattered field from each region of interest or pixels of the object leading to a well-posed solution of the inverse problem. We have already shown elimination of ill-posedness for a one dimensional variation in the object of interest in our prior work (Okhmatovski, et al., IEEE AWPL, Vol. 17, No. 5, pp. 857-860, 2018, "On Use of Inhomogeneous Media for Elimination of Ill-Posedness in the Inverse Problem"; Okhmatovski, et al., IEEE TAP, Vol. 60, No. 5, pp. 2418-2430, 2012, "A Well-Conditioned Non-Iterative Approach to Solution of the Inverse Problem").

We are proposing a new concept that uses a focusing medium which enables localization of the radiation coming from individual regions of the object or pixels of the object. The medium is constructed as a specially constructed collection of antenna array elements with multiple beams of the array overlapping on the individual regions of the object. To ensure the area of overlap of the beams with the region of the object are comparable, a novel technique is utilized to control the width of the beams. Higher contribution of scattered field from pixels of interest is obtained by focusing the medium onto the pixel of interest from multiple directions. Such medium is shown to eliminate ill-posedness of the inverse problem and cast the matrix equation of the discretized inverse source problem into the form with well-conditioned matrix which is directly invertible. Proof of concept will be demonstrated using two dimensional scattering problem under TM polarization.