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Detection of Buried Objects by Means of a SAP Technique: Comparing MUSIC- and SVR-Based Approaches

S. Meschino (1), L. Pajewski (1), M. Pastorino (2), A. Randazzo (2), and G. Schettini (1)

(1) Applied Electronics Dept., "Roma Tre" University, Roma, Italy (smeschino@uniroma3.it), (2) Dynatech Dept., University of Genoa, Genova, Italy (andrea.randazzo@unige.it)

This work is focused on the application of a Sub-Array Processing (SAP) technique to the detection of metallic cylindrical objects embedded in a dielectric half-space.

The identification of buried cables, pipes, conduits, and other cylindrical utilities, is an important problem that has been extensively studied in the last years. Most commonly used approaches are based on the use of electromagnetic sensing: a set of antennas illuminates the ground and the collected echo is analyzed in order to extract information about the scenario and to localize the sought objects [1].

In a SAP approach, algorithms for the estimation of Directions of Arrival (DOAs) are employed [2]: they assume that the sources (in this paper, currents induced on buried targets) are in the far-field region of the receiving array, so that the received wavefront can be considered as planar, and the main angular direction of the field can be estimated. However, in electromagnetic sensing of buried objects, the scatterers are usually quite near to the antennas. Nevertheless, by dividing the whole receiving array in a suitable number of sub-arrays, and by finding a dominant DOA for each one, it is possible to localize objects that are in the far-field of the sub-array, although being in the near-field of the array. The DOAs found by the sub-arrays can be triangulated, obtaining a set of crossings with intersections condensed around object locations.

In this work, the performances of two different DOA algorithms are compared. In particular, a MUltiple SIgnal Classification (MUSIC)-type method [3] and Support Vector Regression (SVR) based approach [4] are employed. The results of a Cylindrical-Wave Approach forward solver are used as input data of the detection procedure [5]. To process the crossing pattern, the region of interest is divided in small windows, and a Poisson model is adopted for the statistical distribution of intersections in the windows. Hypothesis testing procedures are used (imposing a suitable threshold from a desired false-alarm rate), to ascribe each window to the ground or to the sought objects.

Numerical results are presented, for a test scenario with a circular-section cylinder in a dielectric half-space. Different values of the ground permittivity, target size, and its position with respect to the receiving array, are considered. Preliminary results on the application of MUSIC and SVR to multiple-object localization are reported.

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