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Detection of a Buried Dielectric Object by Means of a Sub-Array Processing Technique

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An application to dielectric buried objects is proposed, of a hybrid electromagnetic-statistic approach, developed for the detection and localization of a circular cylinder buried in a lossless half-space. This method had been recently applied to perfectly-conducting underground targets in the proximity of a linear array of receiving antennas.

The results of a cylindrical-wave approach forward solver are used as input data of the detection procedure. The employed sub-array processing method considers several algorithms for the direction of arrival estimation (Bartlett and Capon algorithms, Linear Prediction, Maximum Entropy, Minimum Norm, Pisarenko Harmonic Decomposition, Multiple Signal Classification and Estimation of Signal Parameters via Rotational Invariance Techniques). The direction of arrival approach assumes that the sources (current induced on the buried targets) are in the far-field region of the receiving array, so that the received wavefront can be considered as planar; by dividing the whole array in a suitable number of sub-arrays and finding the dominant angle of arrival for each one, it is possible to localize also scatterers that are in the far-field of the sub-array but in the near-field of the array. By triangulating the found directions of arrival, a set of crossing is obtained: the intersections are condensed around the object locations. To process the crossing pattern, a Poisson statistical model is adopted for the statistical distribution of the intersections; hypothesis testing procedures are employed to identify a collection of small windows containing the target. In particular, by defining a suitable threshold from a desired false-alarm rate, and by dividing the whole region of interest in small windows, it is possible to ascribe each window to the ground or to the searched objects.

In this work numerical results are presented, for a test scenario with a dielectric cylinder in a dielectric half-space. The performances of different direction of arrival algorithms are compared. Different values of the permittivity contrast, of the target size, and of its position with respect to the receiving array, are considered. An empirical method is proposed, to estimate also the scatterer size. The limits of the sub-array processing technique in multiple-object localization are highlighted.

References

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