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Cylindrical-Wave Approach for Electromagnetic Scattering by Subsurface Targets in a Lossy Medium

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The Cylindrical-Wave Approach (CWA) rigorously solves, in the spectral domain, the electromagnetic forward scattering by a finite set of buried two-dimensional perfectly-conducting or dielectric objects [1]-[3]. In this technique, the field scattered by underground objects is represented in terms of a superposition of cylindrical waves. Use is made of the plane-wave spectrum [1] to take into account the interaction of such waves with the planar interface between air and soil, and between different layers eventually present in the ground.

In this work we present the progress we recently made to improve the method. In particular, we have faced the fundamental problem of losses in the ground: this is of significant importance in remote sensing applications, since real soils often have complex permittivity and conductivity, and sometimes also a complex permeability.

First, a convergent closed-form representation of the cylindrical-wave angular spectrum in a generic lossy medium has been found [4]. To obtain this spectrum, the canonical Sommerfeld representation of the first-kind Hankel function of integer order has been used; its integration path has been modified to ensure the integral convergence for complex values of the wavenumber.

Subsequently, the solution to the scattering problem of a plane-wave propagating in air, impinging on the interface with a dissipative medium, and interacting with a buried perfectly-conducting cylinder, has been derived. The developed method may return the field values in each point of the space, both in the near and far zones; moreover it may be applied for any polarization, and for arbitrary values of the cylinder size and of the distance between the cylinder and the air-soil interface.

The theoretical solution has been implemented in a Fortran code. The numerical evaluation of the reflected and transmitted cylindrical wave functions in the presence of lossy media was a critical point: we extended the Gaussian adaptive quadrature formula, employed for the lossless case [2], through the introduction of general complex functions for the oscillation frequencies of the integral kernels.

Finally, several scenarios have been simulated. The numerical results of our code have been compared with both the literature and a commercial software implementing the finite-element method.

We plan to generalize the approach to the case of a dielectric cylinder, and to a finite set of dielectric and metallic cylinders, buried in a dissipative half-space.

References

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