# The Cylindrical Wave Approach and its applications to radar problems

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The solution to scattering problems by buried objects is a task with applications in the remote sensing of the sub-soil with the Ground Penetrating Radar (GPR) [1]. When, instead, objects are not visible as hidden behind a wall, applications are within the Through-the-Wall radar [2], a technique derived by GPR, and optimized to deal with the interaction between the electromagnetic field and the wall.

In both fields of application, modelling of the forward electromagnetic problem is fundamental to understand and reconstruct the target under investigation. According to the radar technique employed, frequency- or time-domain methods may be employed. However, a frequency-domain technique, developed for a monochromatic source, can be extended to implement a pulsed signal with an iterative approach, i.e., through a sampling of its spectrum and reconstruction of the time-domain waveform with an inverse Fast Fourier Transform [3].

The Cylindrical Wave Approach (CWA) is a frequency-domain technique developed to solve, in a semi-analytical way, the scattering by circular cross-section cylinder placed below an interface between to semi-infinite media. The method employs expansion into cylindrical waves to describe the field scattered by the targets. Cylindrical wave expansions are used also to describe the interaction of the field with the interface, i.e., to express a scattered-reflected, and a scattered transmitted field. In this case, the basis functions are expressed through spectral integrals. The method is formulated both for a plane-wave [3] or line-source as monochromatic excitation [4]. For a more flexible application to practical scenarios of GPR, the method has been extended also to a layered geometry, where the targets may be embedded in a dielectric layer [5] or placed below it [6]. The latter geometry has the advantage to be extended also to the modelling of Through-the-Wall problems, where targets are placed in air below a wall. The layered case has been dealt with to take into account all the possible multiple interactions, of reflection or transmission, with the interfaces bounding the layer.

In the numerical implementation of the CWA attention is paid to the evaluation of the spectral integrals used as basis functions of the scattered-reflected and scattered-transmitted fields. In order to keep an accurate evaluation, all the spectral contributions, homogeneous and evanescent, are considered. A compromise between numerical accuracy and computational heaviness is achieved with a suitable choice of basis function in the field expansions. Results of simulation of CWA is useful to check practical cases of radar applications or to be used of input to benchmark new imaging algorithms.

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