Efficient Models of EM Scattering from Objects within a Half-Space Background

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Electromagnetic (EM) scattering analysis of 3-D objects within a half-space background has been investigated for years since its wide applications in remote sensing and target identification. Since the unknowns are only associated with the objects, the method of moments (MoM) based on the Green's functions of half space is one of the most favorable methods, in which the influence of the background has been included in the Green's functions. However, there are always two main difficulties prohibiting its popularity and efficiency for practical applications.

The first difficulty appears in the efficient calculation of the half-space Green's functions which are extremely time-consuming to evaluate. The other difficulty appears in the demand for reducing the CPU time and total memory by using fast algorithms. The multilevel fast multiple algorithm (MLFMA) has been introduced to the case where object is totally within one region, and the method of adaptive cross approximation (ACA) has been applied for objects straddling the interface, due to its nature of Green's function independency.

To solve the difficulties mentioned above, three efficient models of EM scattering from 3-D objects within a half-space background are analyzed in this paper. Firstly, a novel composite dielectric model is proposed and investigated for objects straddling the interface or located in upper region totally. The traditional half-space scattering problem has been cast into a composite dielectric object scattering in the free space by truncating the interface, to avoid the calculation of half-space Green's function that is hard to be calculated analytically and numerically. Furthermore, the proposed method can be accelerated efficiently by MLFMA without any restrictions, compensating the additional cost resulting from the introduction of unknowns by the truncation. Secondly, two approximation models, i.e., cut model and PEC model are also investigated to improve the efficiency further, where cut model represents that the parts of the objects below the interface have been cut out, and PEC model represents that the dielectric interface is deemed as PEC. A variety of numerical examples are studied and yes-no proposals for different models are summarized finally to provide references for engineering applications.