A Generalized Multi-trace Surface Integral Equation Domain Decomposition Method with Optimized Transmission Conditions

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Full wave solution of electromagnetic wave scattering from a multi-scale and complex target with multiple materials has been a major research emphasis for computational electromagntetics. In this work, we shall present our efforts in combating a complex heterogeneous multi-scale electromagnetic scattering problem, viz. a plane wave scattering from a high-definition composite unmanned aerial vehicle (UAV) at X-band. Of particular concern is that this complex platform is partially coated with multi-layer electromagnetic absorbers, which include frequency selective surfaces, multi-layer impedance sheets and magnetic radar absorbing materials. Needless to say, such a multi-scale scattering problem is extremely challenging and taxes heavily on existing surface integral equation methods.

In this work, we present a surface integral equation domain decomposition method (SIE-DDM) to address this challenging large multi-scale EM scattering problem. The proposed SIE-DDM follows a hierarchical domain partitioning strategy. The entire computational domain is decomposed into a series of non-overlapping sub-regions. Each local sub-region is homogeneous with constant material properties and described by a closed surface. Through this decomposition, we have introduced at least two pairs of trace data as unknowns on interfaces between sub-regions. This multi-trace feature admits two major benefits: the localized surface integral equation for the homogeneous sub-region problem is amenable to operator preconditioning; the resulting linear systems of equations readily lend themselves to optimized Schwarz methods. In the method to be presented, we study a new optimized second order transmission condition to further improve the convergence in the SIE-DDM iterations. Numerical results are included to validate the accuracy and demonstrate the versatility of the proposed method.