Analysis of scattering from time varying surfaces with the Generalized Method of Moments: the scalar case

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Transient scattering analysis finds numerous applications in electromagnetics and acoustics. These range from radar to broadband antenna design to integrated electrogmagnetic circuit analysis to imaging to therapy to sonar, etc. While differential equations are the most popular, they suffer from increased degrees of freedom necessary to overcome dispersion errors, imposition of absorbing boundary conditions and volumetric representation of the object. Properly constructed surface integral equations offer path to overcoming these hurdles. However, the principal bottleneck to using these has been (i) stability of the discrete system and (ii) computational complexity. While computational complexity has largely been addressed via the development of PWTD [A. A. Ergin, B. Shanker and E. Michielssen, IEEE AP Mag., 41, 39, 1999] and TDAIM [A.E. Yilmaz, J. M. Jin and E. Michielssen, IEEE TAP, 52, 2692, 2004] algorithms, stability and higher order convergence in time remains a bottleneck.

In all the aforementioned examples, the objects being analyzed are stationary. Specifically, their surfaces are stationary. In some instances, it is also necessary to analyze scattering from objects whose surfaces are time varying. One example that offers itself in acoustics is scattering from and steering of microbubbles. Similar examples occur in speckle imaging. In these examples, it is assumed that time scale of surface dynamics, while significantly smaller than the physics of interrogation, is significant enough to affect the scattering response. The analysis in such problems dictate that the modeling methodology, in addition to being stable while marching on in time, needs to be sufficiently flexible so as to include change in shape. Our approach to solving this coupled non-linear problems will proceed along the following lines: (i) we will develop a transient scattering analysis framework based on the Generalized method of moments that relies on point cloud model to describe the geometry and define approximation spaces, (ii) this will be integrated with a separable approximation for convolution with the retarded potential that has shown to provide a stable and higher order time marching schemes and (iii) this will be integrated with a non-linear solver to update surface description. At the conference, we will present results exploring these dynamics for a candidate problem wherein we will explore these dynamics using a thin dielectric shell approximation to construct a requisite time domain integral equation.