A Discontinuous Galerkin-Boundary Integral Method with Local Time-Stepping for Analyzing Electromagnetic Scattering from Disconnected Objects

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Numerical methods capable of analyzing transient scattering from inhomogeneous objects that reside in an unbounded background medium often solve Maxwell equations directly. These (differential equation-based) solvers call for a field relation that imitates the radiation condition to be enforced on the truncation boundary of the computation domain. This relation is often implemented in the form of exact absorbing boundary conditions (EACs), their localized but approximate versions (ABCs), or perfectly matched layers (PMLs) [1]. However, EACs can only be enforced on planar or spherical boundaries, ABCs are not accurate for fields obliquely incident on the boundaries, and PMLs suffer from late time instabilities and inaccuracies due to spurious reflections at the PML interface.

These bottlenecks can be removed by hybridizing the differential equation solver with the boundary integral (DE-BI) method [2-5]. This approach allows for the fields on the truncation boundary to be formulated in the form of a boundary integral defined over a Huygens' surface enclosing the scatterer. The resulting scheme has several advantages: (i) The radiation condition is mathematically exact, (ii) the truncation boundary conforms to the scatterer's shape and is located very close to its surface, and (iii) locally truncated domains can be introduced individually around disconnected scatterers.

In [5], a discontinuous Galerkin time domain scheme (DGTD) has been hybridized with the time domain boundary integral method (TDBI). The incoming numerical flux on the truncation boundary is used to enforce the radiation condition. The fields required by the flux are computed using the TDBI from the equivalent currents on the Huygens' surface. These currents are obtained from the fields computed by the DGTD. The resulting scheme combines the advantages of the DGTD with those of the hybridization listed above. However, since it uses a time marching scheme with a single time step size, its efficiency degrades for problems involving multiscale disconnected scatterers.

In this work, this issue is alleviated using a local time-stepping (LTS) scheme. The LTS makes use of the fact that the computation domain is decomposed into separate subdomains individually wrapping around disconnected scatterers. The fields in each of these subdomains are locally "marched" in time with a different time step size. During marching, these fields are "coupled" using the TDBI while the difference in time step sizes is accounted for using an interpolation/extrapolation scheme. Numerical examples, which demonstrate the accuracy, efficiency, and applicability of the resulting method, will be presented at the conference.

References

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