A Local Mesh Refinement Scheme for Multi-scale Problems via Huygens' Surfaces

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Multiscale problems represent a challenge for any computational electromagnetics application. Whereas very dense meshes are needed to properly describe the tiny details of structures, hence the behavior of the system, there are many parts that can be approached with coarser meshes. This fact is translated in heavy computational requirements for methods such as surface-integral equation method of moments (SIE-MoM). Instead, there are widespread approaches for this kind of problems, as the multilevel fast multipole algorithm (MLFMA) or matrix compression methods for far-field coupling.

The mesh refinement methods [1,2], which perform somehow an inverse procedure to the matrix compression, have proven to be a suitable method for multiscale problems. These methods consist in approaching the problem through a coarse mesh to obtain a first approximated solution. Then, the mesh is refined up to a point where a fixed accuracy level is met. After the refinement process is finished, an optimal mesh is obtained and can be used to solve the problem with a proper precision.

In order to perform the mesh refinement efficiently, this work proposes the introduction of the Huygens' equivalence theorem to divide the problem into smaller parts isolated from the rest. This permits to perform the mesh refinement locally, allowing SIE-MoM methods to avoid the heavy requirements of a global refined problem. To perform this, the process is similar to the standard mesh refinement. First, the problem is solved using a coarse mesh. Then, each domain is isolated from the others through a Huygens' surface and solved locally. In order to address the problem properly, the contribution from the other domains is added to the local excitation in the right-hand side. In the case of external domains, this is done using the coupling through the Huygens' surface, and the classical procedure in the case of internal domains within the Huygens' surface. A representation of this scheme is shown in Fig. 1.

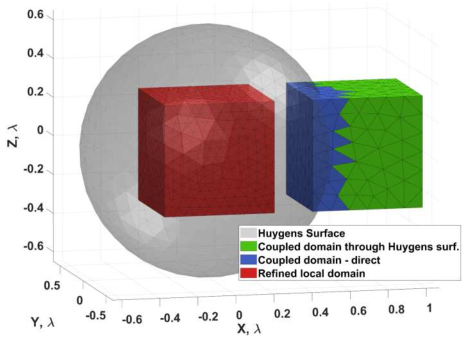

Figure 1. Example of a refined domain isolated from other using a spherical Huygens' surface.

References

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