Adaptive Mesh Refinement using Hanging Edges in 3D Transient Electromagnetic Modeling

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SUMMARY

Numerical forward modeling of electromagnetic fields serves a wide range of applications. It is a key component in inversion routines and allows to analyse suitable experimental configurations. For the design of such experiments, inclusion of realistic geological information such as topography, bathymetry, known fault systems, intrusive bodies, and anthropogenic objects can significantly improve the sucess of field studies.
For these complex settings, spatial discretization using vector-valued finite elements mimicking the electromagnetic fields' behavior on unstructured tetrahedral grids yields high flexibility and accurate results. However, detailed realistic meshes need to be tailored manually to any specific experimental setting in a relatively time-consuming and exhaustive procedure.
Therefore, we propose a straightforward approach of adaptive mesh refinement for vector-valued basis functions thereby naturally satisfying the electromagnetic fields' continuity conditions. We introduce a hanging edge technique, which is easily integrated into a simulation workflow after mesh generation so that mesh modification is performed on the fly, i.e. during runtime. We demonstrate its capabilities using the example of transient electromagnetics and a scenario incorporating the geometry of Stromboli volcano, Italy. We finally legitimate its use through a series of convergence studies.

Keywords: modeling, transient electromagnetics, adaptive mesh refinement