3D inversion of drone EM data -- the DroneSOM project

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Summary

The application of electromagnetic geophysical methods has been actively contributing to various engineering, environmental and economic fields. In Finland, forests and lakes cover more than 75% and 10% of the land area, respectively. This makes geophysical fieldwork such as mineral exploration and groundwater mapping more challenging and costly. Drone measurements are therefore a cost-effective and environmental-friendly approach, especially for large-scale mapping.

The DroneSOM (Drone Geophysics and Self-Organizing Maps) project, funded by EIT RawMaterials, intends to develop drone-based gravity and electromagnetic (EM) exploration instruments and associated data interpretation software. Together with the partners from both academia (i.e., Technical University of Denmark) and industry (i.e., RADAI Oy, Beak Consultants GmbH.), we aim to provide commercial geophysical solutions, as well as free educational tools at the end of the project. In particular, a set of efficient and robust 3D EM modeling and inversion code will be the kernel for EM data interpretation. We hereby present the framework of 3D frequency-domain EM inversion envisioned by project.

In this work, we present numerical examples, where we solve Maxwells equations using a total field electric field formulation. For the model meshing, the code supports rectilinear, curvilinear, and octree grids (Kamm et al., 2020; Xiao et al., 2022). The edge finite element method was used to discretize the diffusion equation derived from Maxwell's equations. To solve the resulting linear system of equations, we use for now the direct solver MUMPS. The object-oriented code is implemented in C++ to allow for easy adaptation for various source and data types.

For the inversion, we use the standard multi-component objective function, which includes data norm and model regularization norm. To solve the adjoint modeling and obtain the model update at each iteration, we use PETSc library. In general, we employ deal.II library (dealii.org/) to perform the heavy computation, such as the modeling equation discretization, linear system equation solving, and inversion model update, as it comes with interface wrappers to MUMPS and PETSc. Currently, the code is parallelised using the MPI framework for both forward and inverse modelling.

Keywords: DroneSOM, 3D, Inversion, frequency-domain, electromagnetic

References

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