FEMALY: A Finite Element MAtlab LibrarY for Electromagnetics

M. Scheunert[1], J. Blechta[2], J. Börner[1], R.-U. Börner[1], M. Eiermann[3], O. Ernst[4] and K. Spitzer[1]
[1]TU Bergakademie Freiberg, Freiberg, Germany, mathias.scheunert@mailserver.tu-freiberg.de
[2]Mathematical Institute, Charles University, Prague, Czechia
[3]Institute for Numerical Mathematics and Optimization, TU Bergakademie Freiberg, Germany
[4]Faculty of Mathematics, TU Chemnitz, Germany

SUMMARY

We present a finite element software library developed in MATLAB for the numerical solution of electromagnetic field problems in both two and three dimensions. It is designed in a modular way to easily plug together fundamental building blocks for various geophysical applications, ranging from direct current to the inductive processes in both frequency and time domain. A Gauss-Newton solver facilitates the inversion of each application. External modules comprise a mesh generator and an equation solver library.
Through its homogeneous software concept, the adaption to any field application is relatively straightforward and makes the code suitable for distribution as an open source software. We introduce the key features of this library including Lagrange and Nédélec finite elements defined on unstructured tetrahedral grids, a Gauss-Newton inversion scheme utilizing linear Raviart-Thomas elements for H1-regularization, and a Rational Best Approximation approach for solving time-integration problems. The library can accommodate various realistic features such as topography, bathymetry or internal voids.
As examples of its application, we outline case studies for magnetotelluric, DC resistivity, controlled source electromagnetic, induced polarization and transient electromagnetic methods in the field and laboratory.

Keywords: Finite elements, unstructured grids, Gauss-Newton, regularization, MATLAB