# FEMALY: A Finite Element MAtlab LibrarY for Electromagnetics

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Abstract

We present a finite element software library written in Matlab for the numerical simulation and inversion of electromagnetic fields in two and three dimensions. It is designed in a modular way to easily plug together fundamental building blocks for various electromagnetic applications from DC to the inductive range in the frequency and even time domain. External modules comprise the mesh generator and the equation solver library. Through its homogeneous software concept the adoption to any field application is relatively simple and makes the code suitable to open source distribution. We introduce the key features of this library including higher-order Lagrange and Nédélec finite elements formulated on unstructured tetrahedral grids, a Gauss-Newton inversion approach using linear Raviart-Thomas elements for H1 regularization, and the ability to incorporate any geometric feature such as topography, bathymetry and internal voids like caves, tunnels and mine buildings. The library is currently being tested with large real data sets to confirm its usefulness as a tool for practical data interpretation. Therefore, case studies for the magnetotelluric, direct current resistivity, controlled source electromagnetic and induced polarization methods in the field and laboratory are briefly outlined as examples with challenging geometric features.

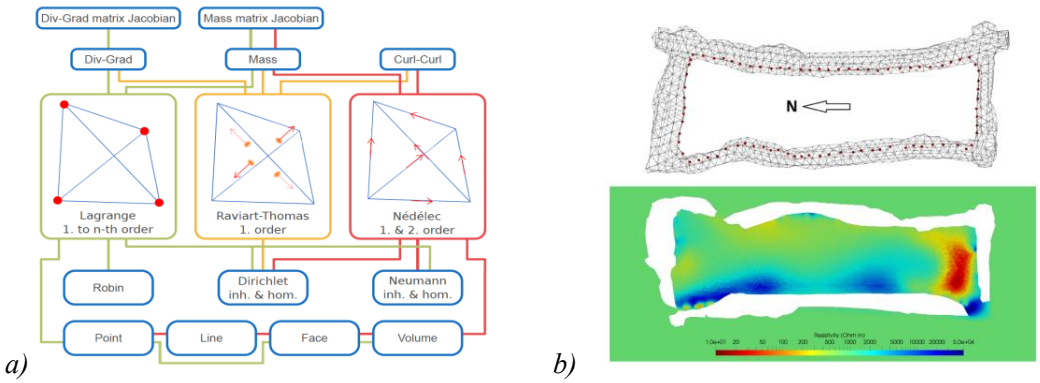


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*Figure 1: a) Building blocks for the forward and inverse modeling procedure: differential operators and their derivatives (top), types of FE (center), boundary conditions and source types (bottom). b) Example application: 3D Inversion of DC resistivity data collected in a subsurface mining gallery in Freiberg's 'Reiche Zeche'. Tunnel geometry with electrode locations (red dots, top) and inversion result (bottom).*

Reference / more information

Spitzer, K., Blechta, J., Börner, J., Börner, R.-U., Eiermann, M., Ernst, O., Scheunert, M., 2023. FEMALY: A Finite Element Matlab Library for Electromagnetics, Extended Abstract, 7th International Symposium on Three-Dimensional Electromagnetics Vancouver, BC, Canada, November 13–15, 2023, 6p, [LINK TO REFERENCE].