MILAMIN 2 – Fast MATLAB FEM solver

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MILAMIN is a free and efficient MATLAB-based two-dimensional FEM solver utilizing unstructured meshes [Dabrowski et al., G-cubed (2008)]. The code consists of steady-state thermal diffusion and incompressible Stokes flow solvers implemented in approximately 200 lines of native MATLAB code. The brevity makes the code easily customizable. An important quality of MILAMIN is speed – it can handle millions of nodes within minutes on one CPU core of a standard desktop computer, and is faster than many commercial solutions.

The new MILAMIN 2 allows three-dimensional modeling. It is designed as a set of functional modules that can be used as building blocks for efficient FEM simulations using MATLAB. The utilities are largely implemented as native MATLAB functions. For performance critical parts we use MUTILS – a suite of compiled MEX functions optimized for shared memory multi-core computers.

The most important features of MILAMIN 2 are:

1. Modular approach to defining, tracking, and discretizing the geometry of the model
2. Interfaces to external mesh generators (e.g., Triangle, Fade2d, T3D) and mesh utilities (e.g., element type conversion, fast point location, boundary extraction)
3. Efficient computation of the stiffness matrix for a wide range of element types, anisotropic materials and three-dimensional problems
4. Fast global matrix assembly using a dedicated MEX function
5. Automatic integration rules
6. Flexible prescription (spatial, temporal, and field functions) and efficient application of Dirichlet, Neuman, and periodic boundary conditions
7. Treatment of transient and non-linear problems
8. Various iterative and multi-level solution strategies
9. Post-processing tools (e.g., numerical integration)
10. Visualization primitives using MATLAB, and VTK export functions

We provide a large number of examples that show how to implement a custom FEM solver using the MILAMIN 2 framework. The examples are MATLAB scripts of increasing complexity that address a given technical topic (e.g., creating meshes, reordering nodes, applying boundary conditions), a given numerical topic (e.g., using various solution strategies, non-linear iterations), or that present a fully-developed solver designed to address a scientific topic (e.g., performing Stokes flow simulations in synthetic porous medium).

References:
Dabrowski, M., M. Krotkiewski, and D. W. Schmid MILAMIN: MATLAB-based finite element method solver for large problems, Geochem. Geophys. Geosyst., 9, Q04030, 2008