FEMhub, a Free Distribution of Open Source Finite Element Codes with Unified Python Interface

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http://femhub.org

SIAM CSE meeting
February 28 - March 4, 2011, Reno, NV

FEMhub

Open-source distribution of Finite Element (FEM) codes with a unified Python interface

Motivation:

- Open source FEM codes scarcely used outside of academia.
- 95% of all FEM simulations are done using commercial FEM software.
- Why is this?

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Our Goal: Establish Fidelity for Open Source FEM Software

- Reduce heterogeneity in installation and usage
- Make them widely available (to *masses*, not only to scientists)
- Facilitate interoperability and comparisons
- Improve reproducibility of results

Open Source FEM Codes

- ALBERTA
- CalculiX
- deal.II
- GetFEM++
- Freefem++
- FEMM
- FETK
- FEMPACK
- FiPy
- OOF
- OFELI
- Phaml
- libMesh
- Code Aster
- DUNE
- FEBio
- Elmer
- FEniCS
- Hermes
- OOFEM
- OpenSees
- OpenFOAM
- ...

Heterogeneity I:

- Operation systems
  - Linux
  - Windows
  - Mac
- Programming languages
  - C/C++
  - Java
  - Fortran
  - Python
  - (even functional languages)
- Download formats
  - *.tgz
  - svn
  - Mercurial
  - Git
- Quality of documentation, examples, tests, ...

Heterogeneity II:

- Dependencies & Interfaces & I/O formats
  - Geometry modeling
  - Mesh generation
  - Matrix solvers
  - Postprocessing
  - Visualization
- FEM technology
  - 2D / 3D / 2D & 3D
  - Simplicial elements (triangles, quadrilaterals)
  - Product elements (quads, bricks, prisms, pyramids)
  - Cartesian / distorted meshes
  - Structured / unstructured meshes
  - Low-order / higher-order
  - Nonadaptive / adaptive
- Problem types
  - First-order / second-order
  - Linear / nonlinear
  - Stationary / time-dependent
  - Scalar / vector-valued
  - Real / complex

Heterogeneity III:

- Physics models
  - Heat transfer
  - Electrostatics
  - Electromagnetics
    - Time-domain
    - Frequency-domain
  - Solid mechanics
    - Elasticity
    - Visco-elasticity
    - Plasticity
  - Fluid mechanics
    - Inviscid / viscous
    - Compressible / incompressible
    - Laminar / turbulent
    - Newtonian / non-newtonian
  - ...
  - Single-physics / multiphysics

Solving Benchmarks

Benchmark = problem where exact solution is available

Sample benchmarks for elliptic PDE:

- W. Mitchell: A Collection of 2D Elliptic Problems for Testing Adaptive Algorithms, NISTIR 7668, 2010.
- P. Solin, O. Certik, L. Korous: Three Anisotropic Benchmarks for Adaptive Finite Element Methods, Appl. Math. Comput., doi:10.1016/j.amc.2010.12.080.

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Response to Mitchell's paper:

- Z. Ma, L. Korous, E. Santiago: Solving a Suite of NIST Benchmark Problems for Adaptive FEM with the Hermes Library, Journal CAM, submitted in January 2011.

Promoting Reproducibility in Publications

Sample papers.

Benchmarks in Hermes

To become part of FEMhub.