Getting started with FEniCS

1. FEniCS overview

FEniCS is a powerful, open-source suite of tools for automated solution of PDEs using finite elements. Part of the power for FEniCS is the ease with which one can create FE solvers by describing PDEs using weak forms in nearly-mathematical notation. The FEniCS project can be found at: http://fenicsproject.org/ with an extensive documentation and examples, see for instance: https://fenicsproject.org/documentation/.

FEniCS includes a number of powerful features, which are described at http://fenicsproject.org/about/features.html. These include:

- Automated solution of variational problems
- Automated error control and adaptivity
- An extensive library of finite elements
- High performance linear algebra through backends to such libraries as PETSc and Trilinos.
- Visualization via a simple interactive plotting function, as well as output in VTK format
- FEniCS can be used from both Python and C++
- Extensive documentation (see for instance: https://fenicsproject.org/documentation/)

2. FEniCS resources

The documentation for FEniCS is extensive. Resources include:

- **FEniCS Demos.** These documented demonstration programs are a great way to learn the different features in FEniCS. They come already packaged in FEniCS when you install it; the appropriate directory depends on your operating system, and the paths can be found here: http://fenicsproject.org/documentation/demos.html#finding-demos
- **Quick Programmer's References.** Some of the classes and functions in DOLFIN are more frequently used than others. The Python implementations are described in http://fenicsproject.org/documentation/dolfin/1.6.0/python/quick_reference.html. See also http://fenicsproject.org/documentation/dolfin/1.6.0/python/genindex.html for the Complete Programmer's References.
- **Getting Help.** See: http://fenicsproject.org/support/

Other resources, some a little outdated and not fully compatible with the latest versions of FEniCS, include:

- **FEniCS Tutorial:** This is the best starting point; it describes the Python interface to FEniCS: http://fenicsproject.org/documentation/tutorial/index.html
  The tutorial is also available as a PDF document: http://fenicsproject.org/_static/tutorial/fenics_tutorial_1.0.pdf
  All of the Python codes described in the tutorial can be downloaded as a tarball from: http://fenicsproject.org/_static/tutorial/fenics_tutorial_examples.tar.gz
  Note: a new FEniCS tutorial version is available at: http://hplgit.github.io/fenics-tutorial/doc/pub/fenics-tutorial-4print.pdf.

- **The FEniCS Book:** All 732 pages of the FEniCS book (*Automated Solution of Differential Equations by the Finite Element Method*) can be downloaded (legally!) from here: http://launchpad.net/fenics-book/trunk/final/+download/fenics-book-2011-10-27-final.pdf
  This is the comprehensive reference to FEniCS, along with many examples of the applications of FEniCS to problems in science and engineering. You will notice that the first chapter of the book is just the FEniCS Tutorial (with some minor editorial differences).

- **The FEniCS Manual.** This is a 200-page excerpt from the FEniCS Book, including the FEniCS Tutorial, an introduction to the finite element method, and documentation of DOLFIN and UFL: http://launchpad.net/fenics-book/trunk/final/+download/fenics-manual-2011-10-31.pdf

3. Installing FEniCS

The current version of hIPPYlib depends on FEniCS (http://fenicsproject.org/) version 1.6. Please follow the install instructions given on the FEniCS page: https://fenicsproject.org/download/ to install the correct FEniCS version, and make sure this is compatible with your system. Below you can find a quick summary for the installation:

- **MacOS 10.10 and 10.11 systems:**

  Download FEniCS 1.6.0 from here: https://fenicsproject.org/download/osx_details.html. Find your MacOS version (either 10.11 or 10.10) and download the appropriate binaries of FEniCS 1.6.0. If you are running bash as default shell, you can add the following line to your profile in your home folder:

  `source /Applications/FEniCS.app/Contents/Resources/share/fenics/fenics.conf`

  Alternatively you can just double-click on the FEniCS icon in your Applications directory and that will generate a new shell preconfigured with the paths that FEniCS needs. Just run FEniCS from within this shell.

  The FEniCS demo programs are located under
  `/Applications/FEniCS.app/Contents/Resources/share/dolfin/demo`

- **MacOS 10.9:**

  Download FEniCS 1.5.0 from here: http://fenicsproject.org/download/older_releases.html#older-releases. Find your MacOS version and download the appropriate binaries of FEniCS 1.5.0. Note FEniCS 1.5.0 will not be supported by future releases of hIPPYlib.

- **Ubuntu LTS 14.04 or above:**[1]
  Open a shell and run the following commands:
  `sudo add-apt-repository ppa:fenics-packages/fenics-1.6.x`
  `sudo apt-get update`
  `sudo apt-get install -y fenics`

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[1]The same installation instructions may also work for different version of Ubuntu or other Debian-based versions of Linux.

```
sudo apt-get dist-upgrade
sudo apt-get install -y ipython-notebook
sudo apt-get install -y paraview
sudo apt-get install -y git
```

If in the future you decide to uninstall FEniCS and remove all its dependencies, you can run the following commands:

```
sudo apt-get purge --auto-remove fenics
sudo ppa-purge ppa:fenics-packages/fenics-1.6.x
```

FEniCS demo programs are located under
`/usr/share/dolfin/demo/` .

4. Check the FEniCS installation

To check the FEniCS installation on your system, go to the demo folder (see above for the exact location of this folder in your system) and run demo_poisson.py by typing the following at the command lines:

```
cd documented/poisson/python/
python demo_poisson.py
```

After compilation, you'll get a message saying

```
Solving linear variational problem.
```

and a simple plot of the solution will pop up in a new window. If you mouse over the Help tag in the low left, you'll get a list of some keyboard commands for interactive visualization. You can quit this run by typing q or Q. The Poisson equation code poisson_demo.py is described extensively in the FEniCS Tutorial (pages 5–15), as well as online at
http://fenicsproject.org/documentation/dolfin/1.6.0/python/demo/documented/poisson/python/documentation.html