Lab 01 - Introduction

Numerical Solution of PDEs Using the Finite Element Method

MHPC P2.13_seed

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1. Setup
   - Edit file `~/.bashrc` to contain the line
     `source /scratch/smr2909/enable.sh`
     and close and re-open your terminal. You can use `gedit ~/.bashrc`
     to open an editor. Check that this worked by typing `echo $DEAL_II_DIR`
     You should see `/scratch/smr2909/deal.II/install` printed to the screen.
   - Please note, inside `/scratch/smr2909/` there are the following folders:
     - `labs/` – a folder with exercise sheets and example programs
     - `bin/` and `apps/` – several programs (you shouldn't need to access them directly, because they will be imported into your PATH automatically)
     - `libs/`, `candi/`, `candi-build` – libraries deal.II depends on.
     - `deal.II` – source, build, and installation of deal.II.
     - `deal.II/dealii/examples/` – all tutorial programs.
   - to make a copy of tutorial 1, configure, compile, and run it:

     ```
     cp -r /scratch/smr2909/labs/lab01/step-1 ~/
     cd ~/step-1
     cmake .
     make
     ./step-1
     ```

   - IDE: open `qtcreator .`
2. Tasks for tutorial step-1:
   1. See documentation at
      https://www.dealii.org/8.5.0/doxygen/deal.II/step_1.html
   2. Compile and run inside qtcreator and look at the output.
   3. Comment out the `.set_manifold(0, ...)` line in `second_grid()`. What happens now?
   4. Create an image of an L-shape domain (add a function third_grid() to step-1) with one global refinement.
   5. Now change the output format of the previous example to vtk and open the new file in paraview.
   6. Refine the L-shaped mesh adaptively around the re-entrant corner several times but with a twist: refine all cells with the distance between the center of the cell and re-entrant corner is smaller than 1/3.
   7. Output mesh two as an svg file instead of eps. Open it in a browser to display it (firefox for example).

8. Create a helper function that takes a reference to a Triangulation and prints the following information: number of levels, number of cells, number of active cells. Test this with all of your meshes.

9. Generate a circle using `GridGenerator::hyper_ball()` in 2d: use a SphericalManifold everywhere, only on the boundary, or on all cells except the center cell and refine the mesh globally twice.

10. Go into `second_grid()` and remove the last line (`.set_manifold(0);`). The program will crash when you run it. Try to find out what is going on by debugging the program ("Debug" -> "Start debugging" in qtcreator) and stepping through the function `second_grid()`. You can fix this problem in a more elegant way than putting the line you removed back in. How? See the tutorial description for more info.

11. Bonus: Create a mesh that represents the surface of a torus and refine it 2 times globally. Output to vtk format and check the output. Note that your Triangulation needs to be of type `Triangulation<2,3>`, which we will discuss later this week.

12. Bonus: Take a look at step-49 and read the included .msh file in your modified step-1 program.