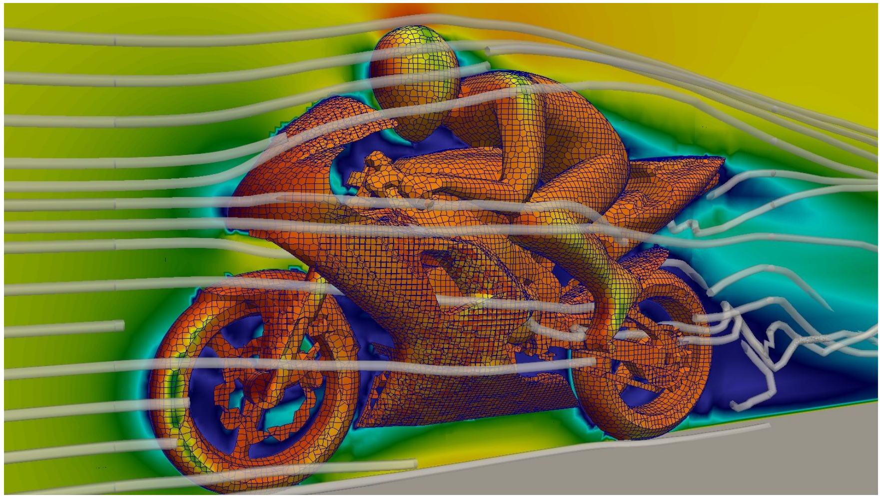
Open Source Computational Fluid Dynamics



An MSc course to gain extended knowledge in Computational Fluid Dynamics (CFD) using open source software.

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Mesh generation with GMSH

- GMSH: open source (GPLv2+) software for meshing
- Website: http://www.geuz.org/gmsh
- Originally designed for finite element method (FEM)
- OpenFOAM (FVM) can effectively use GMSH meshes
  - 1. In GMSH:
    - Create geometry in GUI or GEO file
    - Define mesh resolution requirements in GEO file
    - Define boundary conditions in GEO file
    - Run: **`gmsh -3 yourGeometry.geo`**
  - 2. In OpenFOAM:
    - Run: **`gmshToFoam yourGeometry.msh`**

Example GEO file

```
lc = 0.05;               // characteristic length
Mesh.VolumeFaces = 1;    // display faces of volume mesh
Mesh.RecombineAll = 1;   // triangulation -> quadrilateral mesh
Mesh.Algorithm = 8;      // Delaunay for quads
```

Parameters

```
Point(1) = {0, 0, 0, lc};
Point(2) = {1, 0, 0, 0.5*lc};
Point(3) = {1.2, 0.2, 0, 0.5*lc};
Point(4) = {2, 0.2, 0, lc};
Point(5) = {2, 0.4, 0, lc};
Point(6) = {-0, 0.4, 0, lc};
```

Points

```
Line(1) = {1, 2};
Line(2) = {2, 3};
Line(3) = {3, 4};
Line(4) = {4, 5};
Line(5) = {5, 6};
Line(6) = {6, 1};
```

Lines

```
Line Loop(7) = {5, 6, 1, 2, 3, 4};
Plane Surface(8) = {7};
```

2D surface

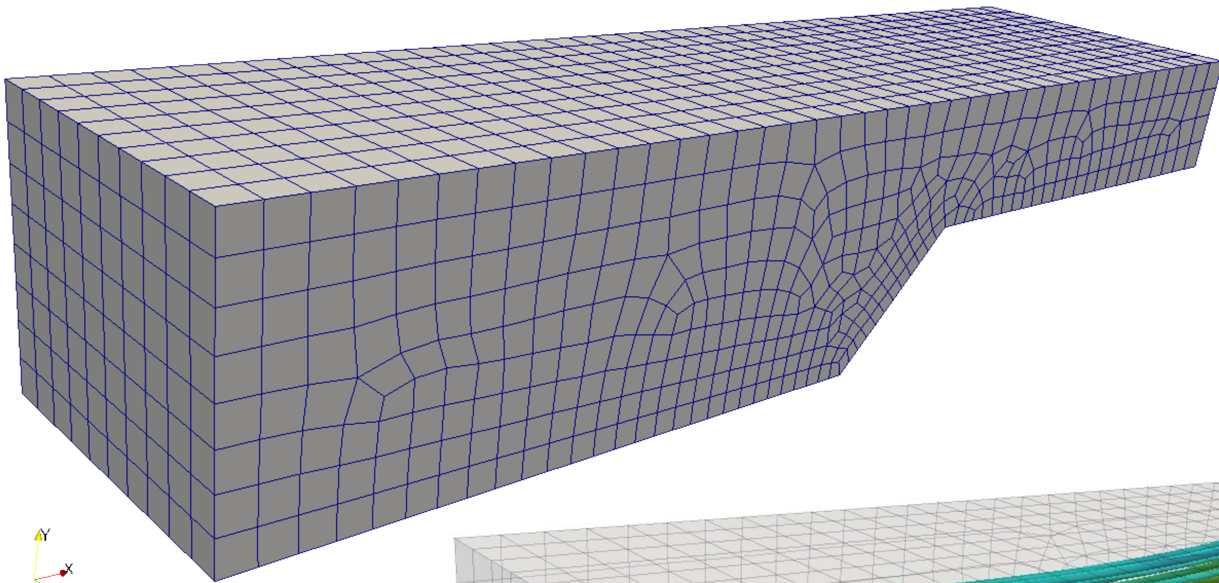
```
Extrude {0, 0, 0.5} {
  Surface{8}; Layers{10}; Recombine;
}
```

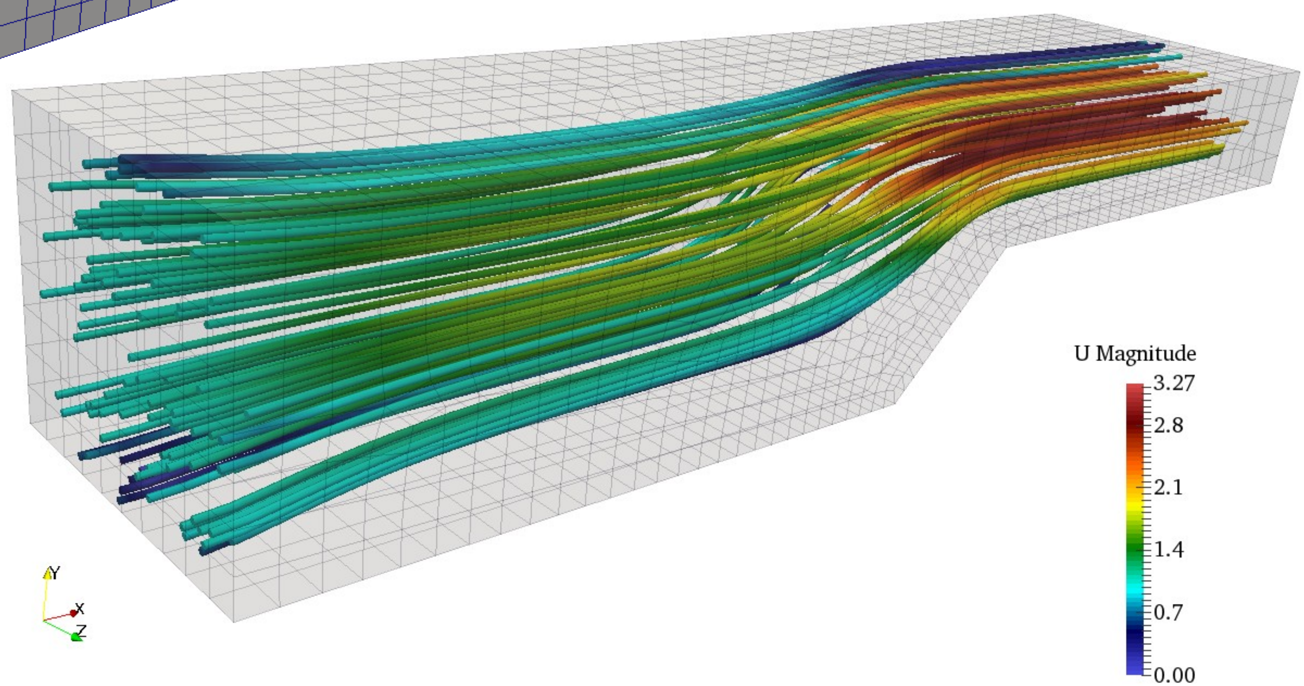
2D extrusion → 3D mesh

```
Physical Surface("inlet") = {23};
Physical Surface("wall") = {27, 31, 35, 40, 19, 8};
Physical Surface("outlet") = {39};
Physical Volume(44) = {1};
```

Boundary conditions
+ volume definition!

Mesh and OpenFOAM flow simulation





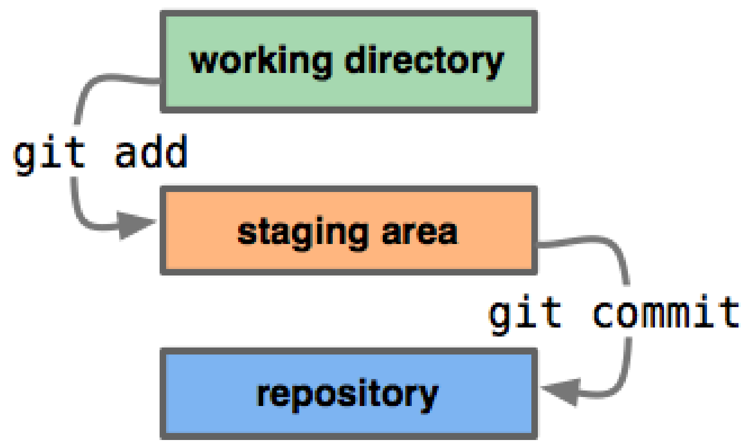
Advanced programming in OpenFOAM

- Revision control: git
- Debugging:
  - *Info* statements
    1. Insert *Info* statements to the source code
    2. Re-compile code
    3. Find and remove bugs
    4. Remove *Info* statements
  - DebugSwitches in $WM_PROJECT_DIR/etc/controlDict

    e.g. modify *lduMatrix* to 2
  - GNU Debugger (GDB)

First git commit

```
# Global configuration of GIT system:
git config --global user.name "Zoltan Hernadi"
git config --global user.email "zhernadi"
git config --global core.editor "gedit"
git config --global color.ui true
git init # initialize repo
echo "My content" > my_file
git add .
git commit -m "Initial commit"
```



Using git

```
git status
git log
git diff           # difference between working directory and stage+repo
git diff --staged # difference between stage and repo
git rm file_to_delete.txt # remove file
git mv old_file.txt new_place/new_file.txt # rename/move
git diff changed_file.txt

# Undo changes in working directory (copy from repo to working directory):
git checkout -- changed_file.txt

# Undo changes in stage:
git reset HEAD changed_file.txt

# Copy old version of file from repo to stage:
git checkout a3076290213d4 -- file_old_version.txt

# Undo full commit by creating a new commit:
git revert c32d0130762

git clean -n # show untracked files to be removed in working directory
git clean -f # remove untracked files in working directory
```

Using git

```
git help
git help log

git log --oneline
git show a3076290213d4
git show HEAD^
git show HEAD~1
git show HEAD^^^
git show HEAD~3

git remote                  # list remotes
git push                    # from local to remote
git fetch                   # from remote to local
git merge origin/master     # after fetch: merge to local
git pull                    # git fetch + git merge
```

OpenFOAM git repository:
https://github.com/OpenFOAM

Debugging with GDB

- Compile OpenFOAM with debug flag:
  `WM_COMPILE_OPTION=Debug wmake`
- either re-compile the complete code of OpenFOAM
- or accept that you can debug the re-compiled code only

GDB commands:

- b: break (set breakpoint)
- r: run (start program)
- n: next (execute next program line)
- c: continue
- l: list nearby source-code lines
- l 12: list source-code lines nearby line 12
- info locals: show local variables
- p var: print variable content
- p var = 1: change variable content to 1
- help name: show information about GDB command name

OpenFOAM information sources

- Main website:
  http://www.openfoam.org
- Unofficial OpenFOAM wiki:
  http://openfoamwiki.net
- CFD Online Forum:
  http://www.cfd-online.com/Forums/openfoam/
- PhD course:
  http://www.tfd.chalmers.se/~hani/kurser/OS_CFD/
- OpenFOAM workshop:
  http://openfoamworkshop.org
- OpenFOAM training:
  http://www.openfoam.com/training/