Alternative pre-processing tools for Elmer

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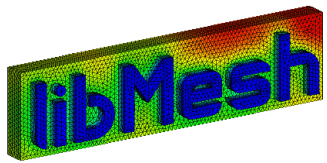
Mesh generation capabilities of Elmer suite

- **ElmerGrid**
  - native generation of simple structured meshes
- **ElmerGUI**
  - plugins for tetgen, netgen and ElmerGrid

- No geometry generation tools to speak about
- No capability for multibody Delaunay meshing
- Limited control over mesh quality and density
- Complex meshes must be created by other tools!

Open Source software for Computational Engineering



Open source software in computational engineering

- Academicly rooted stuff is top notch
  - Linear algebra, solver libraries
  - PetSc, Trilinos, OpenFOAM, LibMesh++, …
- CAD and mesh generation not that competitive
  - OpenCASCADE legacy software
  - Mesh generators netgen, tetgen, Gmsh are clearly academic
  - Also for OpenFOAM there is development of commercial preprocessing tools
- Users may need to build their own workflows from the most suitable tools
  - Also in combination with commerial software

Open Source Mesh Generation Software for Elmer

- **ElmerGrid**: native to Elmer
  - Simple structured mesh generation
  - Simple mesh manipulation
  - Usable via ElmerGUI
- **ElmerMesh2D**
  - Obsolite 2D Delaunay mesh generator usable via the old ElmerFront
- **Netgen**
  - Can write linear meshes in Elmer format
  - Usable also as ElmerGUI plug-in
- **Tetgen**
  - Usable as ElmerGUI plug-in
- **Gmsh**
  - Includes geometry definition tools
  - ElmerGUI/ElmerGrid can read the format msh format
- **SALOME**
  - ElmerGrid can read the unv format written by SALOME
  - Preliminary version for direct interface to Elmer
- **FreeCAD**
  - Open source community driven effort also based on OpenCascade
  - Preliminary version for direct interface to Elmer

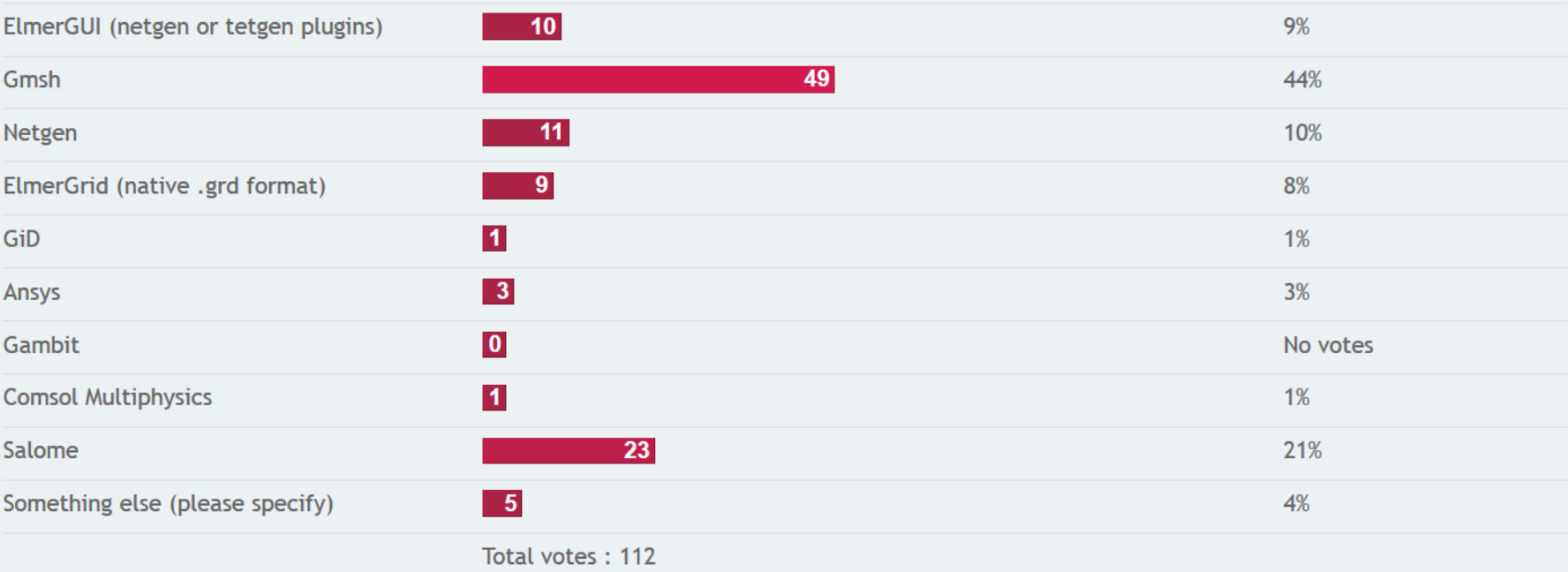
Commercial mesh generation software for Elmer

- GiD
  - Relatively inexpensive
  - With an add-on module can directly write Elmer format
- Comsol multiphysics
  - ElmerGUI/ElmerGrid can read .**mphtxt** format
- HyperMesh
  - Usable via the UNV export
- …

- Ask for your format:
  - Writing a parser from ascii-mesh file usually not big a deal

Mesh generation tools – Poll (5/2018)

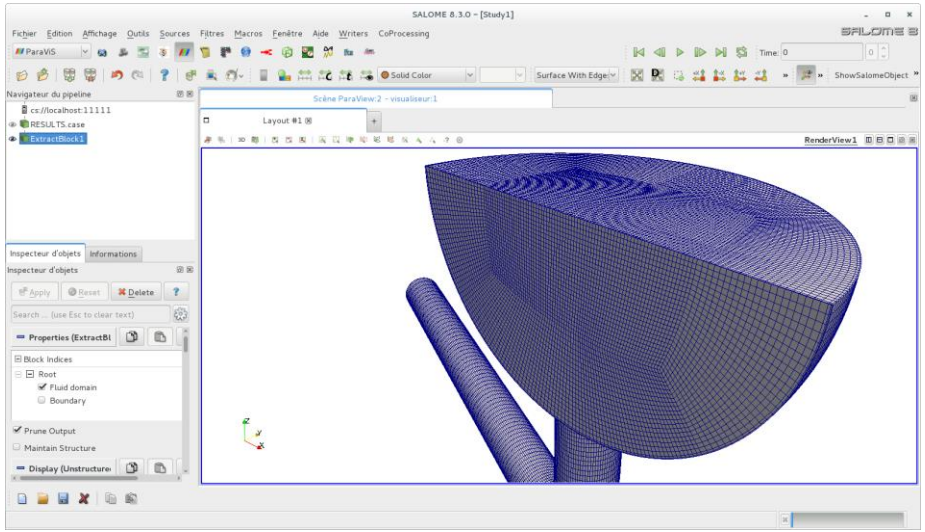
What mesh generation software do you use with Elmer?



CAD – SALOME

http://www.salome-platform.org/

- SALOME is an open-source software that provides a generic platform for Pre- and Post-Processing for numerical simulation. It is based on an open and flexible architecture made of reusable components.
- SALOME is a cross-platform solution. It is distributed as open-source software under the terms of the GNU LGPL license. You can download both the source code and the executables from this site.
- SALOME can be used as standalone application for, or as a platform for integration of the external third-party numerical codes.



Using Salome with Elmer

There are some instructions in Wiki

- http://www.elmerfem.org/wiki/index.php/Salome
- The **.unv** format provides a channel from Salome to Elmer
  - **ElmerGrid 8 2 test.unv –autoclean**
  - Or direct opening with ElmerGUI
- Unv import of ElmerGrid tries to maintain the names and save them to **mesh.names** file of mesh directory
  - Set ”Use Mesh Names = True” to Simulation section
- There is active development of Elmer plug-in by the open source community
  - Follow discussion on the Elmer forum

Elmer interface in SALOME

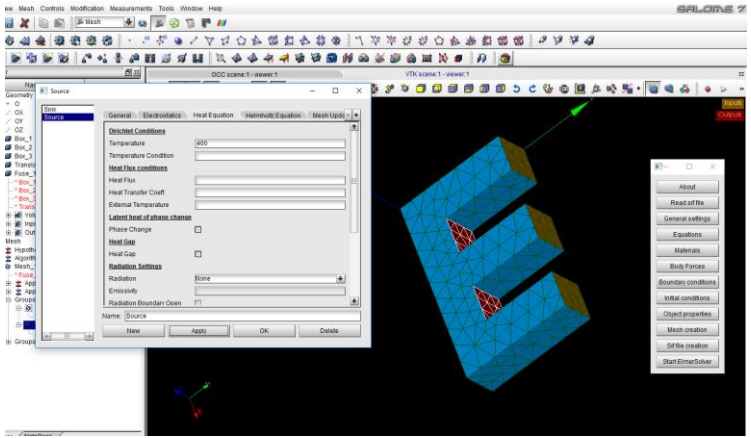
(Open source development by Rainer Jacob and Matthias Zenker)

Motivation:

- Salome already offers CAD, mesh creation and post processing via ParaView
- multiple loops of Salome <-> Elmer, if a geometry is not straight forward and mesh quality vs. time is critical

Solution

- Replace the ElmerGUI by an interface to the ElmerSolver that is directly accessible from Salome
- interface mimics the essential GUI functions for setting up and running a simulation
- Seamless integration into Salome by using the Object Browser and the object properties inside Salome
- Keep Elmers xml-solver files to reduce maintenance
- Log files for export/archiving the Solver output

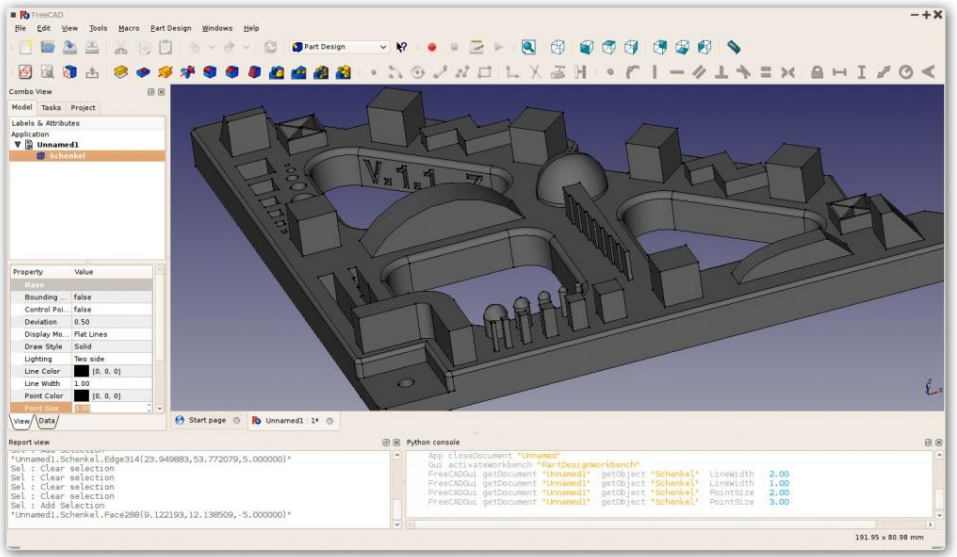


Demo: https://youtu.be/D2-dp4UxblY

FreeCAD

https://www.freecadweb.org/

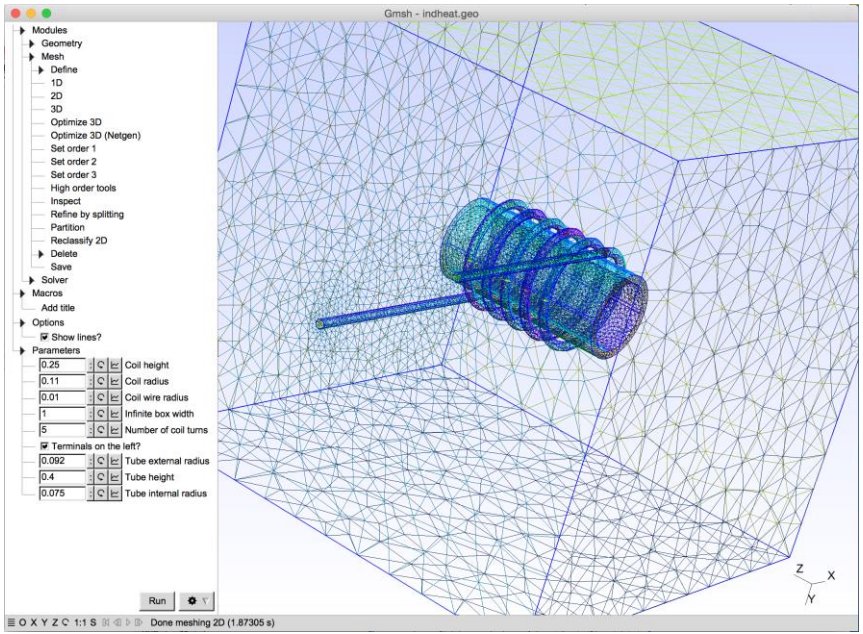
- FreeCAD is a parametric 3D modeler made primarily to design real-life objects of any size.
- Parametric modeling allows you to easily modify your design by going back into your model history and changing its parameters.
- FreeCAD is open-source and highly customizable, scriptable and extensible.
- FreeCAD is multiplatfom (Windows, Mac and Linux), and reads and writes many open file formats such as STEP, IGES, STL, SVG, DXF, OBJ, IFC, DAE and many others.



Gmsh

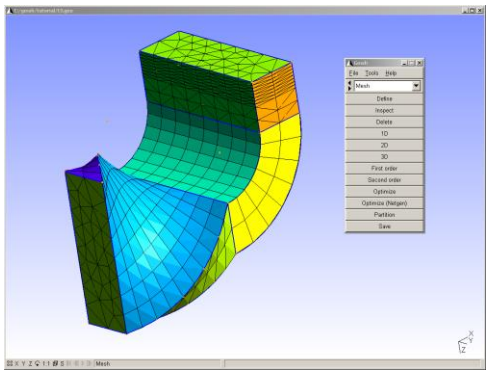
http://gmsh.info

- Written by C. Geuzaine and J.-F. Remacle
- Gmsh is a free 3D finite element grid generator with a build-in CAD engine and post-processor
- Its design goal is to provide a fast, light and user-friendly meshing tool with parametric input
- Gmsh is built around four modules:
  geometry, mesh, solver and post-processing.
- The specification of any input to these modules is done either interactively using the graphical user interface or in ASCII text files using Gmsh's own scripting language.
- Probably the most popular academic mesh generation for finite element method



Using Gmsh with Elmer

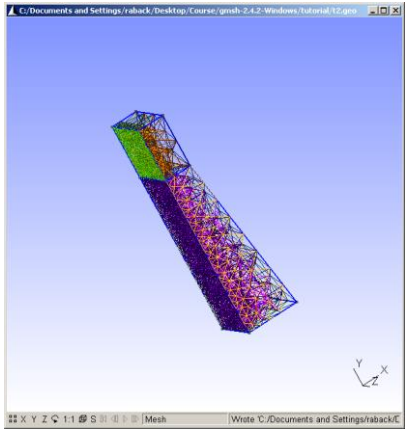
- Saving of the mesh in native gmsh format
  - Suffix .msh
- Usually saving all geometric entities is most robust method
  - Elmer automatically drops lower dimensional entities
  - Elmer renumbers BCs and bodies with 1,2,3,….

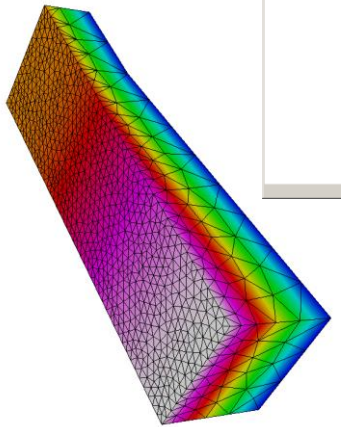


- In Gmsh:
  File -> Save as
  Filename: test.msh
  MSH Options
  Version 2.0 ASCII
  Save all (ignore physical groups)
- In ElmerGUI
  File -> Open : test.msh
- Or ElmerGrid:
  ElmerGrid 14 2 test.msh -autoclean
  (creates a mesh file in directory test)

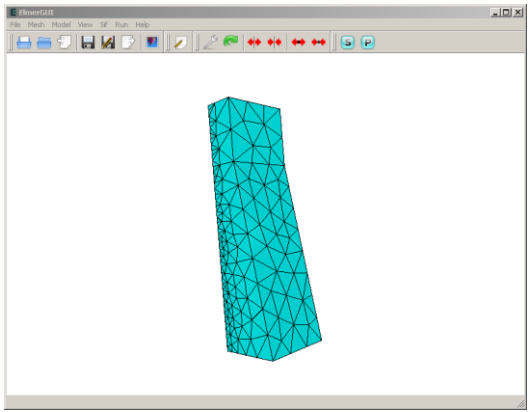
Exercise: Gmsh to Elmer export

- Start gmsh.exe
- Load a existing tutorial in Gmsh
  - t1-t6
- Create the default mesh for it
  - Mesh -> 1D, 2D, (3D)
  - A global size factor may be found at
    Options – Mesh – General – Max. Element size
- Open the mesh in ElmerGUI
- Perform a simple thermal analysis





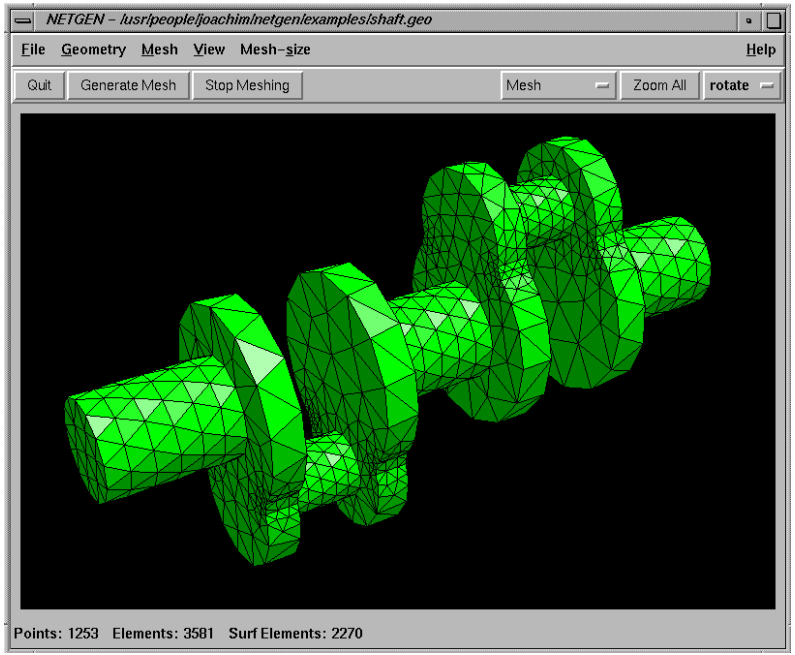
Tutorial 2 of Gmsh



Netgen

http://ngsolve.org/

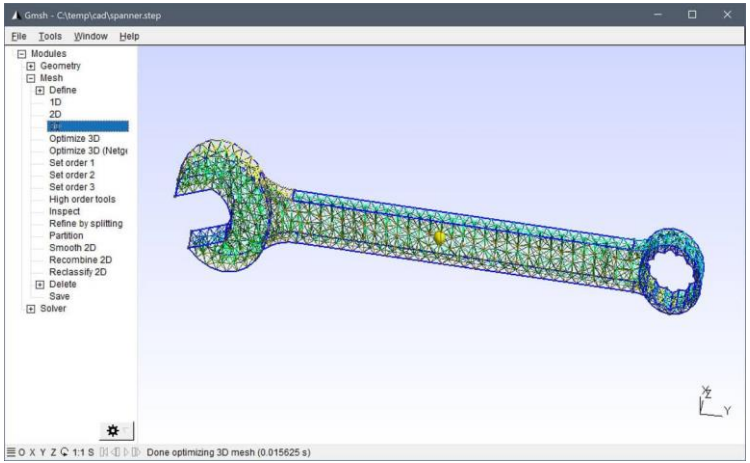
- Developed mainly by Joachim Schöberl
- An automatic 2D/3D tetrahedral mesh generator
- Accepts input from constructive solid geometry (CSG) or boundary representation (BRep) from STL file format
- Connection to OpenCASCADE deals with IGES and STEP files
- Modules for mesh optimization and mesh refinement
- LGPL library
- Netgen as a library is utilized by a large number of GUI projects
- Directly writes meshes in Elmer format (linear only)



GiD

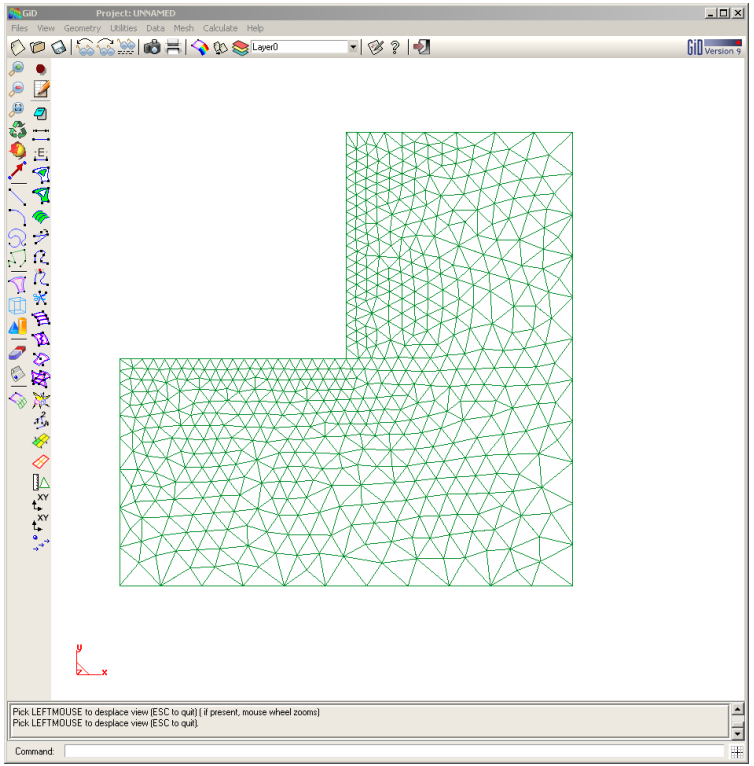
http://www.gidhome.com

- GiD is devoped at CIMNE, Barcelona
- GiD is a universal, adaptive and user-friendly pre and postprocessor for numerical simulations in science and engineering.
- Designed to cover all the common needs in the numerical simulations field from pre to post-processing: geometrical modeling, effective definition of analysis data, meshing, data transfer to analysis software, as well as the visualization of numerical results.
- A good compromise between features and price
- Enables creation of hybrid meshes (not well supported in Gmsh)
- Elmer plugin for writing meshes in Elmer exist



Using GID with Elmer

- Requires special plugins that enable problemtype "Elmer"
- Saves Elmer mesh files directly
- For more details see: http://www.nic.funet.fi/pub/sci/physics/elmer/macros/GiD2Elmer/



Summary of Pre-Processing Workflows in Elmer

- Simple academic structured
  - ElmerGrid -> ElmerSolver
- Intermediate academic
  - Gmsh -> ElmerGrid/ElmerGUI -> ElmerSolver
- Complex free
  - SALOME/FreeCAD -> ElmerGrid -> ElmerSolver
- Complex commercial
  - GiD -> ElmerSolver

- And many more….