SALOME PLATFORM and TetGen for Polyhedral Mesh Generation

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1. Introduction

Recently developed porous body approach codes such as SPACE[1] and CUPID[2] require a CAD system to estimate the porosity. Since they use the unstructured mesh and they also require reliable mesh generation system. The combination of CAD system and mesh generation system is necessary to cope with a large number of cells and the complex fluid system with structural materials inside. In the past, a CAD system Pro/Engineer[3] and mesh generator Pointwise[4] were evaluated for this application. But, the cost of those commercial CAD and mesh generator is sometimes a great burden.

Therefore, efforts have been made to set up a mesh generation system with open source programs. The evaluation of the TetGen[5] has been made in focusing the application for the polyhedral mesh generation[6].

In this paper, SALOME[7] will be evaluated for the efforts in conjunction with TetGen. In section 2, review will be made on the CAD and mesh generation capability of SALOME. Code combination and tests procedure will be described in section 3. Conclusion will be followed.

2. Review on SALOME and TetGen

2.1 SALOME Platform

SALOME is 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. As shown in figure 1, SALOME consists of many modules.

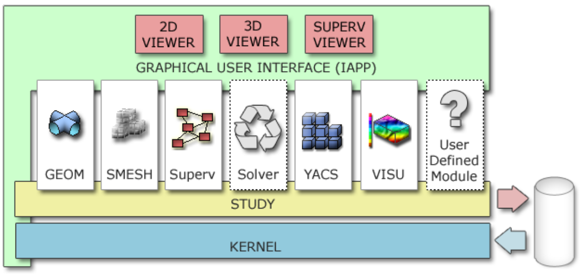

Fig. 1. SALOME Architecture.

SALOME is a cross-platform solution. It is distributed as open-source software under the terms of the GNU[8] GPL license. SALOME can be used as standalone application for generation of CAD models, their preparation for numerical calculations and post-processing of the calculation results. SALOME can also be used as a platform for integration of the external third-party numerical codes to produce a new application for the full life-cycle management of CAD models. It supports interoperability between CAD modeling and computation software. It makes easier the integration of new components into heterogeneous systems for numerical computation. It sets the priority to multi-physics coupling between computation software.

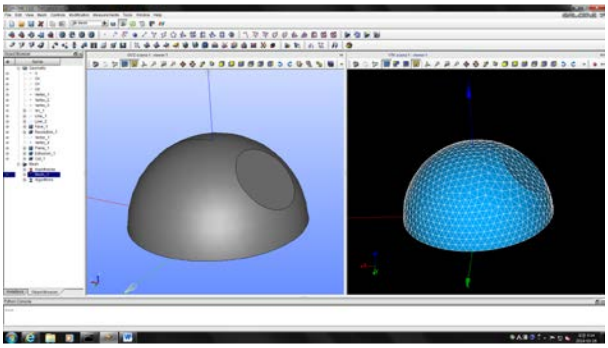

Fig. 2. SALOME GUI, Half-sphere with Flat Face Cut

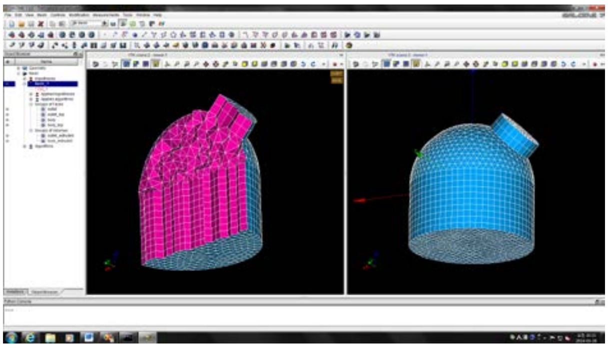

Fig. 3. Extrusion

It provides a generic user-friendly and efficient user interface, which helps to reduce the costs and delays of carrying out the studies. It reduces training time to the specific time for learning the software solution based on this platform. It provides access to all functionalities via the integrated Python console. It create/modify, import/export (IGES, STEP, BREP), repair/clean CAD models. It can mesh CAD models, edit mesh, check mesh quality, import/export mesh (MED, UNV, DAT, STL). It can handle physical properties and quantities attached to geometrical items. It performs computation using one or more external solvers. It displays computation results.

As shown in the figure 2, GUI for SALOME consists of basically four parts. Top part is filled with tool buttons. Left column is occupied by the directory structure of the handling data. Right side of it is presented with CAD window and its mesh view. A solid model, "half-sphere with flat face cut" is generated by the open source CAD OpenCascade[9]. Tetrahedral mesh generation relies on the mesh generator Netgen[10]. The mesh is shown in the figure as well with the VTK viewer[11]. The Extrusion capability is shown in figure 3.

2.2 TetGen Mesh Generator

As a mesh generator, with a three-dimensional domain, defined by its boundary (such as a surface mesh), TetGen generates the boundary constrained (Delaunay) tetrahedralization, conforming (Delaunay) tetrahedralization, quality (Delaunay) mesh. The latter is nicely graded and the tetrahedra have circum-radius to shortest edge ratio bounded. For a three-dimensional point set, the Delaunay tetrahedralization and convex hull can be generated. The code, written in C++, may be compiled into an executable program or a library for integrating into other applications. All major operating systems are supported. It is open source code under the GPL.

An investigation to construct a polyhedral mesh generation system has been made using the TetGen. It was a successful effort and some result is shown in figure 4. TetGen generates polyhedral mesh for the half sphere with flat cut. STL input file is necessary, that is generated by the mesh generator that can handle CAD file such as IGES format. Formerly, Pointwise was used but SALOME is used for the purpose this time.

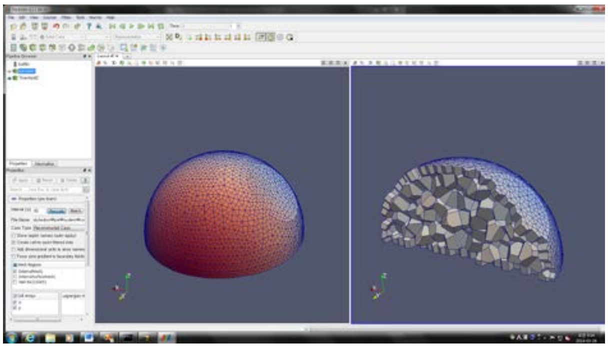

Fig. 4. TetGen generated Polyhedral Mesh.

As one can see from this comment, one of the conspicuous problems to use TetGen is that it can't handle CAD model. It only accepts processed geometric systems such as POLY or STL file formats. It is inevitable for TetGen to be integrated with some CAD to be a full pledged polyhedral meshing system. This is the reason why the investigation is being made, on combining TetGen with SALOME that has CAD capability.

3. Integrating TetGen with SALOME

There are several tasks to integrate TetGen with SALOME. Programming codes that handle data transfer between SALOME and TetGen is the most important task. Even though the data structure of the SALOME is well defined it is not a trivial task to understand them correctly. Data structure in TetGen is already well understood during the last investigation. Since the TetGen is a single file C++ code inserting the code directly into SALOME code is no so difficult. One of the most difficult problems is to remove unnecessary edges on the flat face as shown in the figure 5. Vertex reattachment to the solid is also very difficult problem which is being solved.

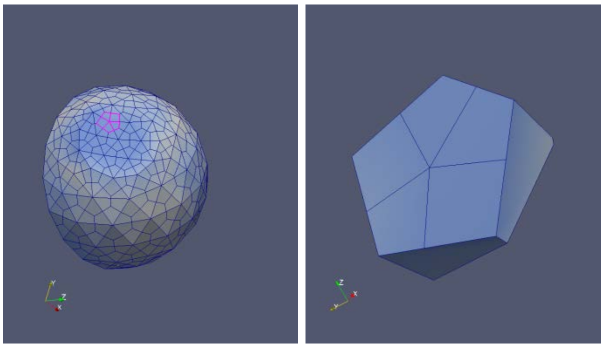

Fig. 5. Removable edges on flat face of polyhedral cell.

4. Conclusions

SALOME and TetGen codes are being integrated to construct robust polyhedral mesh generator. Edge removal on the flat surface and vertex reattachment to the solid are two challenging tasks.

It is worthwhile to point out that the Python script capability of the SALOME should be fully utilized for the future investigation.

REFERENCES

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