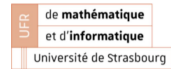


KINETIC AND BUILDING LOD2



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Introduction

In the context of developing energy simulation applications for buildings, there is a need for more sophisticated emulation tools.

- Exa-MA Project : A French initiative under the Numpex project aimed at developing exascale applications for simulation.
- Cemosis and Hidalgo2: Collaborating to port the Ktirio Urban Building application to exascale computing power.

Context

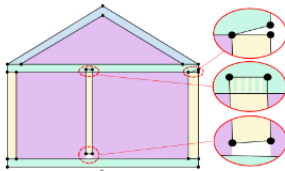


Figure: Mesh with issues

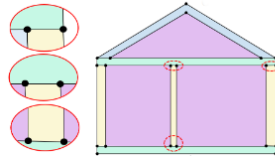


Figure: Mesh without issues

Issue with orientation

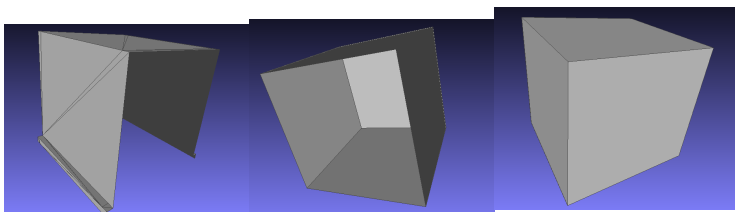


Figure: Cube not oriented

Figure: Cube badly oriented

Figure: Cube oriented by CGAL

Self Intersection issue

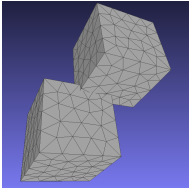


Figure: Two cube self intersecting

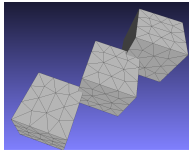


Figure: Two cubes intersecting a third one

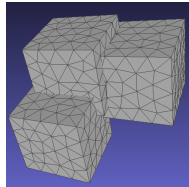


Figure: Three cubes self intersecting

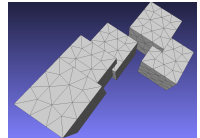


Figure: Five cubes intersecting randomly

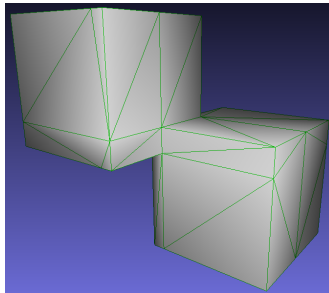


Figure: Two Cubes fixed

All other result in a execution error

Objectives

- Check the validity of the Mesh
- Create a workflow for automatic generation using KSR Algorithm
- Keep the correspondence of surfaces between both meshes
- Run some simulations using the Feel++ library

CGAL

- C++ library for geometric calculations, providing data structures for mesh generation and manipulation.

The main packages utilized are:

- `CGAL::Polygon_mesh_processing`
- `CGAL::Surface_mesh`
- `CGAL::Point_set_processing`
- `CGAL::IO_streams`
- `CGAL::AABB_tree`

File Format

- IFC : Standart for buildding data modeling,similar to class oriented code
- CityGML : 3D format for city modeling with representation of geographic details
- STL : 3D Modeling format
- OBJ :A standard file format for 3D models
- OFF : A file format for 3D mesh data
- PLY : A file format for 3D mesh data,stocking the cloud point of the mesh
- MSH : A file format for mesh data use by GMSH software

Software

- Github : Platforme for collaborating work on a project
- Visual Studio Code : Versatil tools for coding with various extensions
- Paraview : Open-source data analysis and visualisation
- Meshlab : A tool for processing,editing,visualisation of 3D mesh
- GMSH : a 3D finite element mesh generator

Data

The following Data were given by Vincent Chabannes

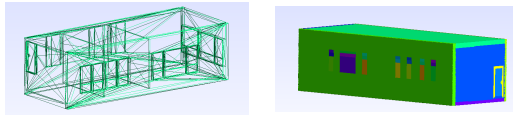
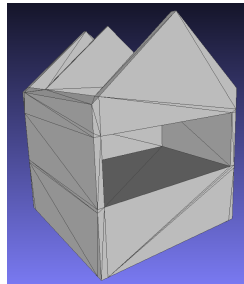
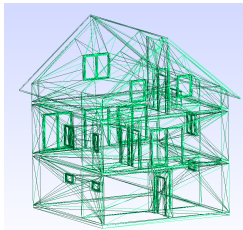


Figure: Three zones mesh



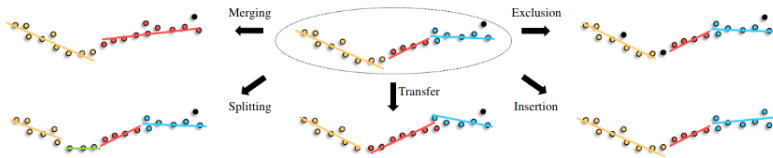
Kinetic

We get information from a INRIA report [1] Kinetic algorithm is an geometric algorithm generate 3D mesh from a point clouds,it uses geometric primitive with an energy based model to fit the primitives to the model.

Energy formule:

$$U(x) = w_f U_f(x) + w_s U_s(x) + w_c U_c(x)$$

to calculate the best primitive
to fit the mesh. then we have a list of geometric operation on each primitive



preprocessing

To improve Kinetic outcome we pre-process the mesh :

- Isotropic remeshing of the mesh
- Unified and regularize the mesh with grid simplify
- Fix self Intersection
- Calcul normals

Labelling

Issue: Inria developed a method to preserve the semantic information of IFC elements, but it has not yet been implemented in CGAL.

Two potential solutions:

- Modify the Kinetic Solver to recognize and utilize markers on each point used to form a shape.
- Compare the input and output meshes to apply the same markers to the closest faces.

Labelling

Exemple of result of second solutions:

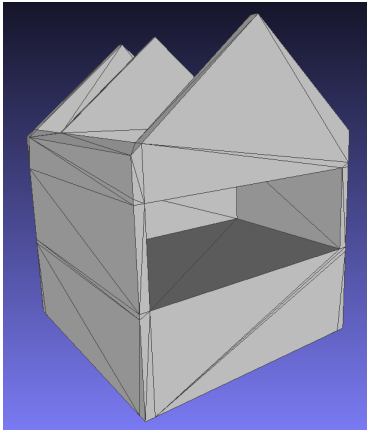


Figure: Input Mesh

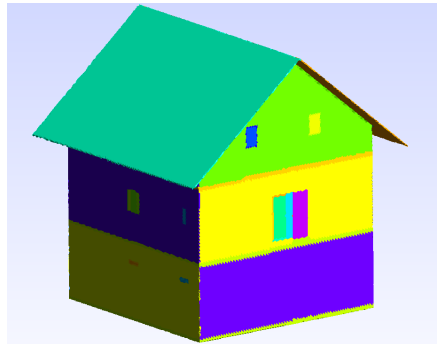


Figure: Output Mesh

Metric

We also want to add method to check the quality off the output mesh

- Properties Check (closed,connected,triangulated...)
- Correspondance between input and output

To check the Correspondance between mesh, we can compare bounding box of each labelled elements.

Table: Bounding Box value

% of marker correct	Three Zones	ACJasmin
<5%	22/57	3/82
between 5 and 10 %	11/57	7/82
between 10 and 20 %	13/57	9/82

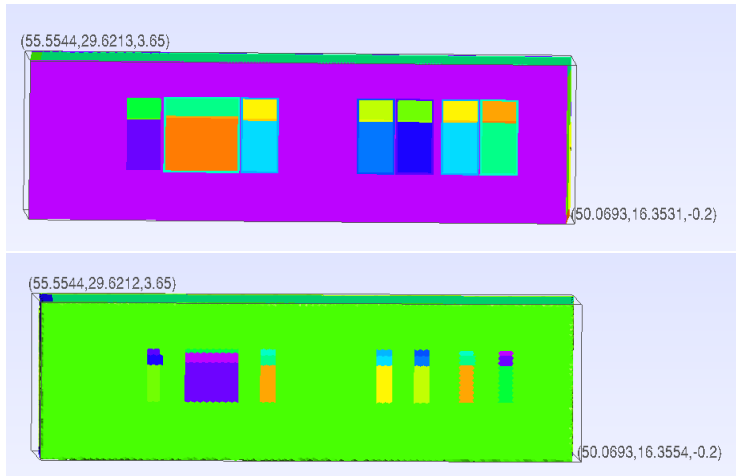


Figure: Three zones Bounding Boxe comparaiison

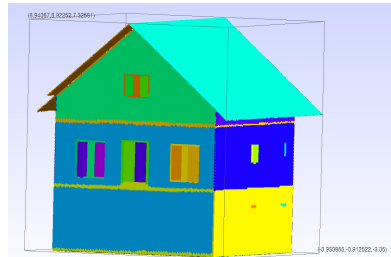
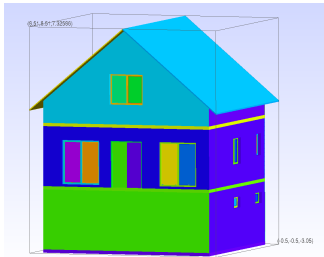


Figure: ACJasmin Bounding Box comparison

Function implemented

- checkProperties
- gridSimplify
- remesh
- KSR

test

- test on Surface Mesh Check
- test on Kinetic algorithm
- test on Point set class and manipulation function

Point cloud

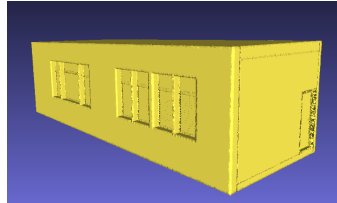
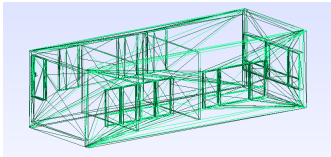


Figure: Three zones mesh point cloud

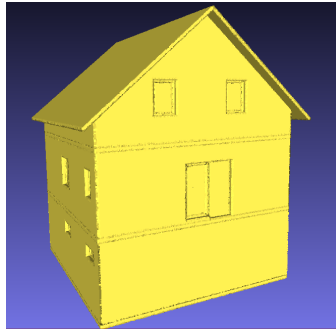
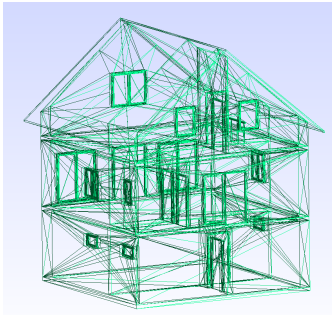


Figure: ACJasmin mesh point cloud

Comparison of Kinetic Outcome

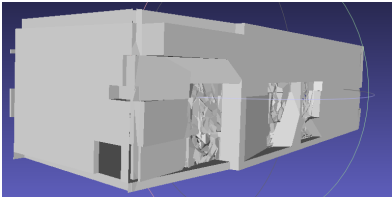


Figure: Old KSR outcome

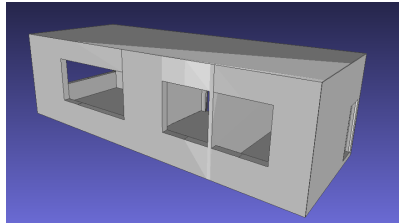


Figure: New KSR outcome

Comparison of 3 Zone Results

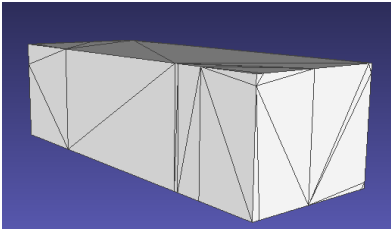


Figure: 3 Zone 500

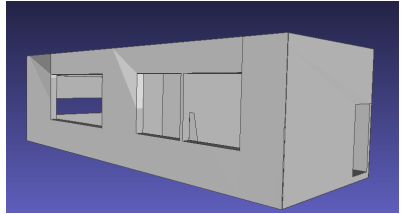


Figure: 3 Zones 45

Comparison of Jasmin Images

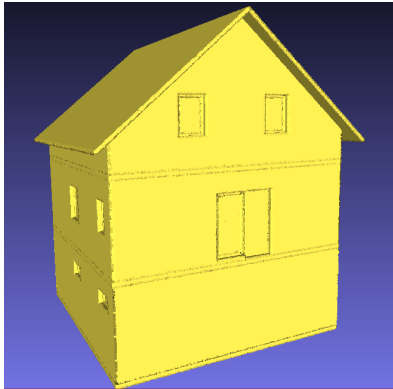


Figure: Jasmin Ply

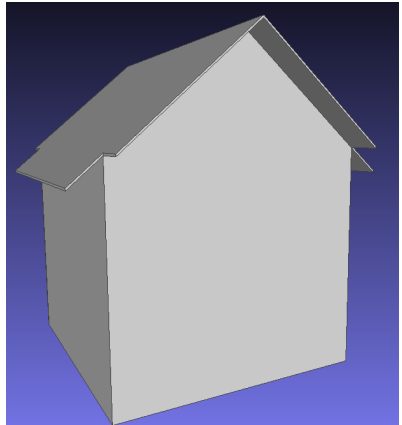


Figure: Jasmin Image

Self Intersection fixing

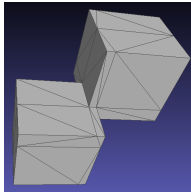


Figure: Same
result as intro

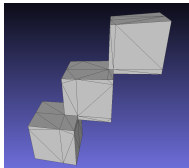


Figure: Worked

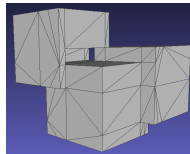


Figure: Worked

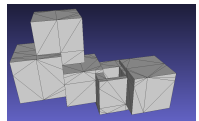


Figure: Worked

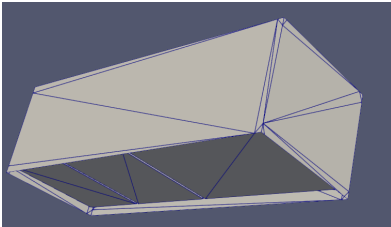


Figure: Refined Zones

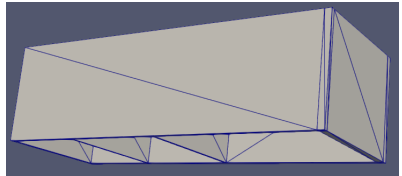


Figure: Not Refined Zones

Comparison of Refined and Not Refined Zones

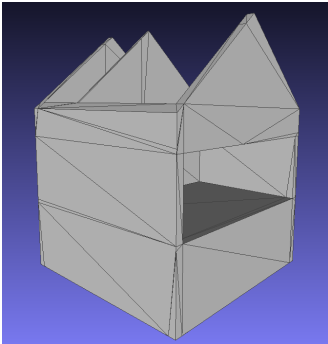


Figure: ACJAsmin Refined

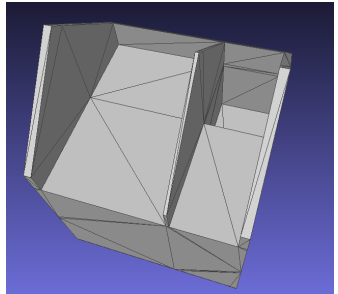


Figure: Jasmin Hole

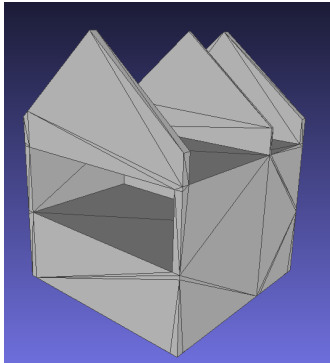


Figure: ACJAsmin Not Refined

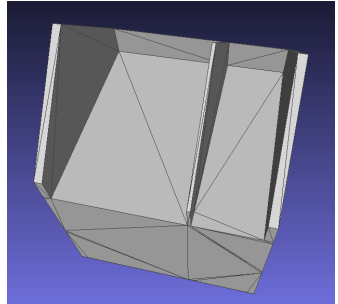


Figure: Jasmin Not Refined Roof

Comparison of ACJASMIN Results

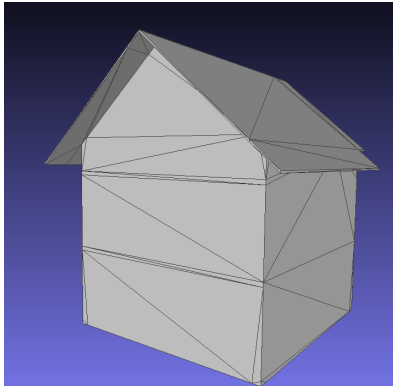


Figure: ACJASMIN Refined

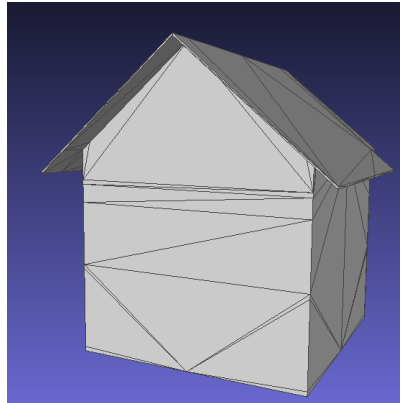


Figure: ACJASMIN Not Refined

Comparison of performance

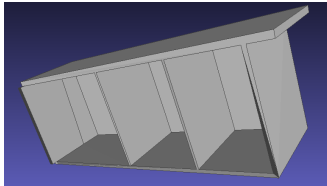


Figure: Execution times 125s

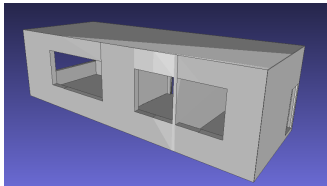


Figure: Execution times 3s

Execution Time with Our Workflow on Three Zones

Parameters	Default	mino=2000	minp=500	minp=100
Shape detection	7.97s	8.18s	5.76s	1.62s
Kinetic space partition	0.22s	0.22s	0.36s	1.35s
Total execution	8.2s	8.41s	6.13s	2.98s

Table: Execution time with our workflow on Three Zones





Table: Execution time on ACJasmin






default	minp=3000,dist=0.08	minp=2000,dist=0.08	minp=1200,dist=0.08
407s	58s	39.8s	31.5s
0.4s	0.8s	0.7s	0.9s
407.5s	58.8s	40s	32.5s





Conclusion

- From result overview: Better results and performance, but could not tried to apply FEM to the mesh.
- From personnal overview: earned how to code with an unknown package and the importance of team communication.

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