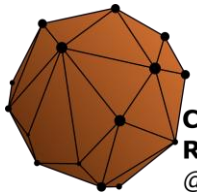

Computational
Rheology
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How to use Blender to generate a mesh with an awful geometry

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Topics

Part 1	**1) Introduction** • Blender a open source software • STL files overview • Most common STL file errors **2) How to repair a STL geometry in Blender?** • Blender basics (workspace and shortcuts) • Tools and tips • Tools and unusual tips
Part 2	**3) Case study** • Geometry preparation for mesh generation • Mesh generation with different refinement levels • Compare the original and corrected meshes **4) Conclusion**

Introduction

What is an STL file?

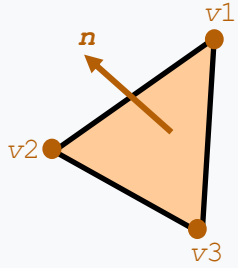
An **STL file** is a **triangulated surface** used mainly to describe the surface geometry of a 3D watertight model.

The (usual closed) surface of the CAD model is discretized by mesh of triangles, which comprises 3 elements:

1. Vertices (points)
2. Edges (lines between vertices)
3. Faces (triangles delimited by edges)

ASCII STL format

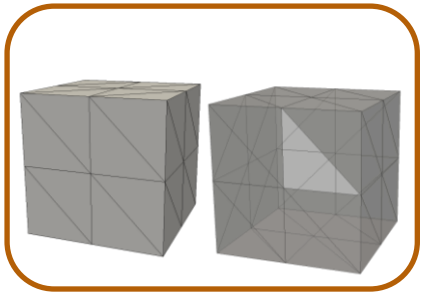
```
solid name

facet normal ni nj nk
   outer loop
      vertex v1x v1y v1z
      vertex v2x v2y v2z
      vertex v3x v3y v3z
   endloop
endfacet

endsolid name
```



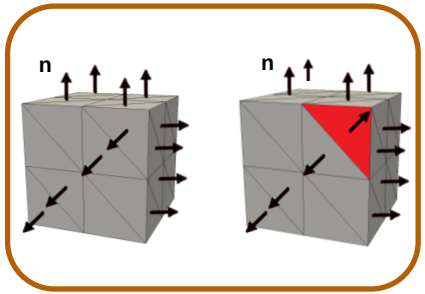
Each triangle also has a normal vector, which defines the side of the triangle facing outward.

Introduction

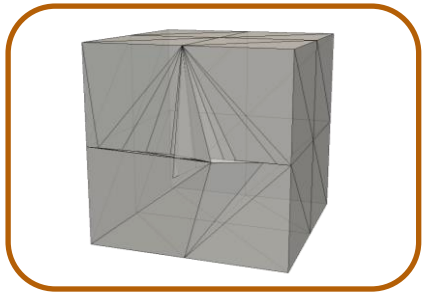
The most common errors of STL files?



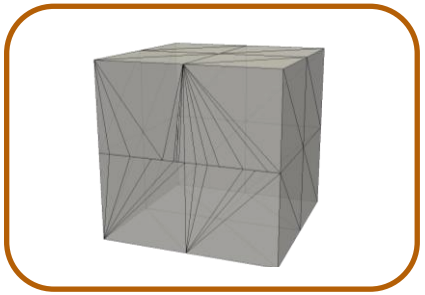
Holes or gaps in a mesh



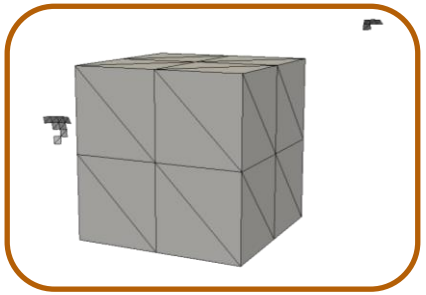
Flipped normal



Intersecting and overlapping triangles



Bad edges



Noise shells

STL file quality

A correct STL-based model is characterized by **closed and connected triangles** that **don't overlap** and where every edge shared by two triangles. However, when converting from CAD to STL, **errors can frequently arise**.

Methodology validation

Check Surface Mesh

```
>> checkSurfaceMesh *.stl
```

Before STL correction

Surface mesh consists of **64 manifolds**!!

Surface mesh has **open boundaries**!!

Surface mesh has **non-manifold edges**!!

Surface mesh has some **bad-quality triangles** with angles smaller than 1.0 deg!!

Found **self-intersecting parts** in the surface mesh!!

Found **overlapping parts** in the surface mesh!!

Found **6 checks** indicating potential problems.

End

After STL correction

Surface mesh consists of a **single manifold**.

No open edges found in the surface mesh.

Surface does not have **any non-manifold edges**.

Surface mesh consists of a **single region**.

No sliver triangles found.

No self-intersections found.

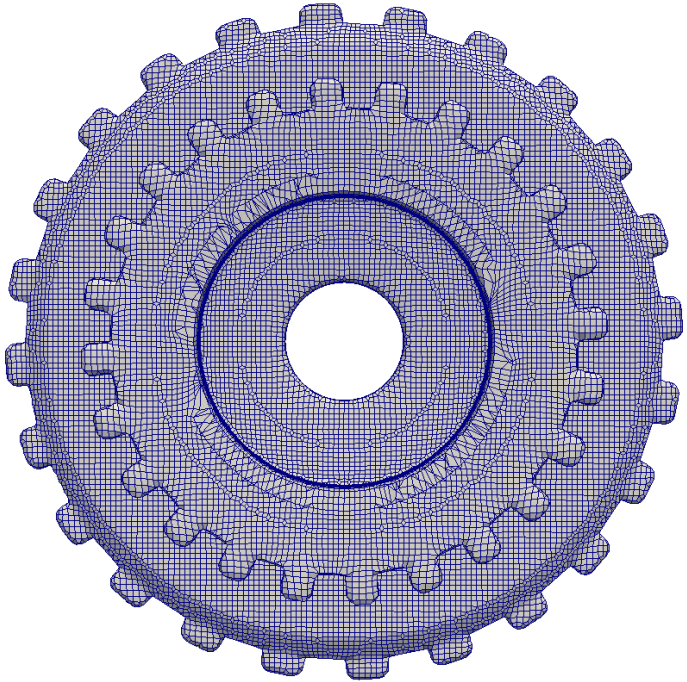
Surface passes all checks.

End

Methodology validation

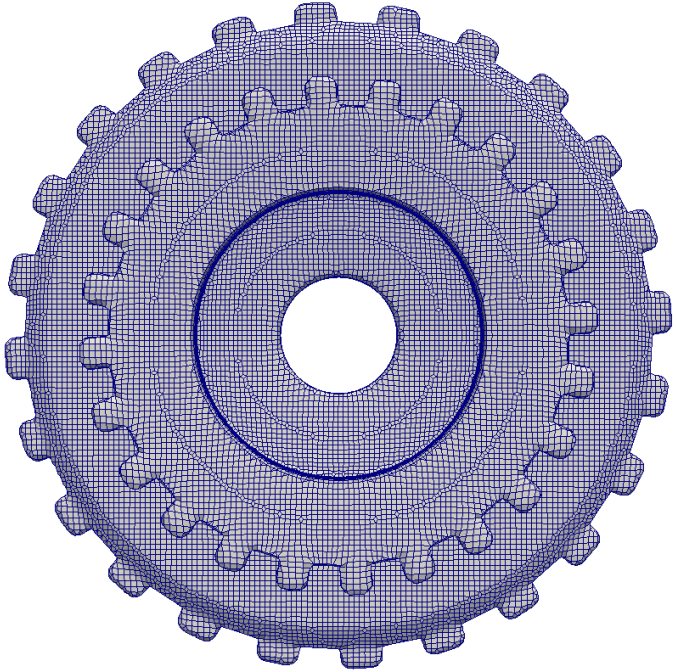
>> Cartesian Mesh (cfMesh) -> checkMesh

Before STL correction



2 non-orthogonal and 2 skew faces
Failed 1 mesh checks

After STL correction



Mesh OK

Methodology validation

Mesh Refinement

STL		Mesh Refinement Level									
		1	2	3	4	5	6	7	8	9	10
Original	Mesh generation	✓	✓	✓	✓	✗	✗	✗	✗	✗	✗
	`checkMesh` output	✗	✗	✗	✗	–	–	–	–	–	–
Corrected	Mesh generation	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	`checkMesh` output	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Conclusion

- **Blender and the presented tools** allows an efficient manipulation of the geometries.
- The **3D print toolbox** was able to detect and indicate the location of all errors pointed out by the **`checkSurfaceMesh`** utility.
- The errors reported by the **`checkSurfaceMesh`** utility and **Blender toolbox** limited the generation of appropriate computational meshes.
- **Blender and the presented tools** proved to be efficient to help solving some difficulties usually faced in preprocessing tasks.
- The **snappyHexMesh addon** proved to be efficient in creating the files needed to generate the computational mesh minimizing the user intervention.

References

[1] Juretic, F. (2015). cfMesh User Guide. Creative Fields, Ltd – www.cfmesh.com

[2] OpenFOAM – The open source CFD toolbox. Available from: https://www.openfoam.com [Accessed: 3 February 2021]

[3] Community BO. Blender - a 3D modelling and rendering package [Internet]. Stichting Blender Foundation, Amsterdam. Available from: http://www.blender.org/ [Accessed: 3 February 2021]

[4] Blender Manual - Add-ons Category Listings. Available from: https://docs.blender.org/manual/en/latest/addons/index.html [Accessed: 3 February 2021]

[5] Liu, F., Zhou, H., & Li, D. (2009). Repair of STL errors. International Journal of Production Research, 47(1), 105-118.

[6] Leong, K. F., Chua, C. K., & Ng, Y. M. (1996). A study of stereolithography file errors and repair. Part 1. Generic solution. The International Journal of Advanced Manufacturing Technology, 12(6), 407-414.

[7] Szilvśi-Nagy, M., & Matyasi, G. Y. (2003). Analysis of STL files. Mathematical and computer modelling, 38(7-9), 945-960.

[8] SnappyHexMesh GUI Addon for Blender - Available from: https://snappyhexmesh-gui.readthedocs.io/en/latest/snappy_gui.html [Accessed: 3 February 2021]