

STLCutter.jl

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<http://github.com/pmartorell/STLCutters.jl>

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Performed tests

Experiments from issue #11

1.1. Relative position - robustness test

- ▶ Set of 13 geometries
- ▶ Constant background mesh h -refinement
- ▶ 17 relative positions ($\Delta x = 10^{-17:-1}$)
- ▶ 17 rotation angles ($\theta = 10^{-17:-1}$)

2.1. h -refinement - robustness test

- ▶ 1.1. geometries
- ▶ 6 constant h -refinements

3. Large geometry dataset

- ▶ 5k geometries filtered from Thingi10k
- ▶ Unique criterion for background mesh refinement: maximum of 100 divisions per direction

1.1. Relative position - Robustness test

Setup

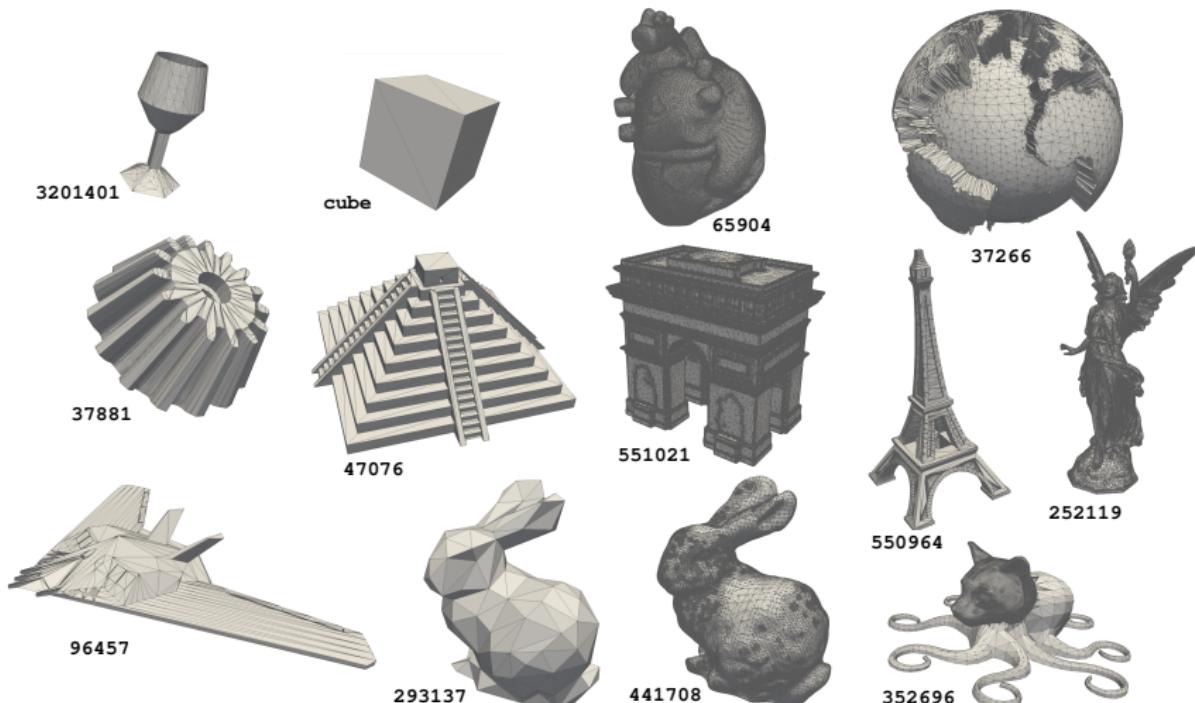
13 STLs; 17 relative positions; 17 rotation angles; $\{\Delta x, \theta\} = 10^{-17:-1}$



1.1. Relative position - Robustness test

Setup

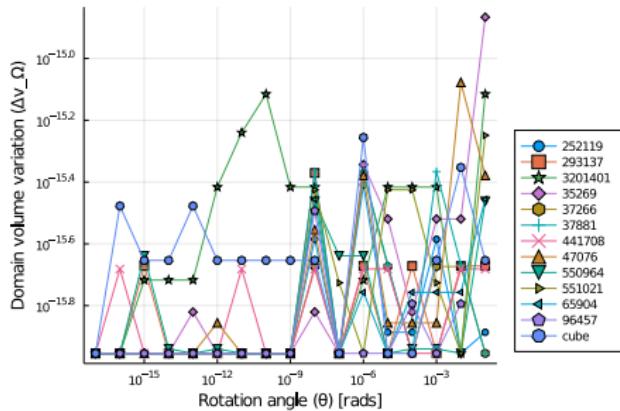
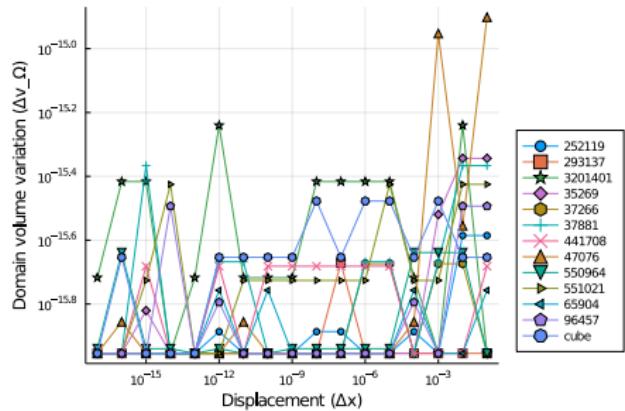
13 STLs; 17 relative positions; 17 rotation angles; $\{\Delta x, \theta\} = 10^{-17:-1}$



1.1. Relative position - Robustness test

Domain volume variation

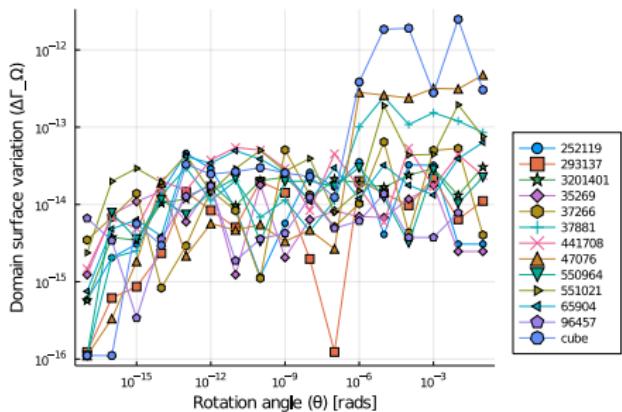
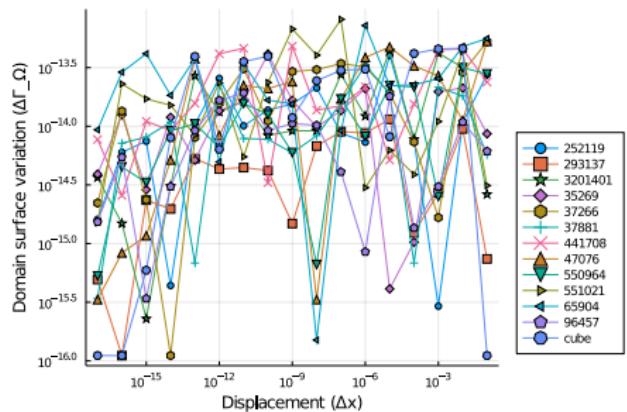
- Maximum volume variation $< 10^{-14}$



1.1. Relative position - Robustness test

Domain volume variation

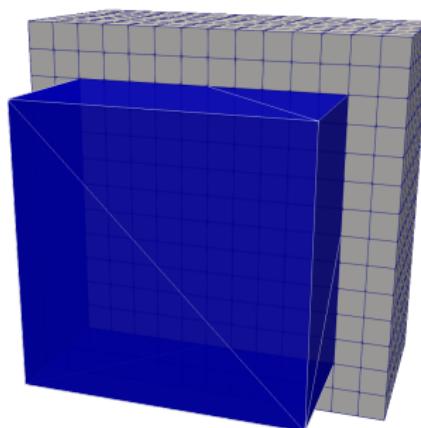
- Maximum volume variation $< 10^{-11}$
- Rotations introduce more rounding errors at planes



2.1. h -refinement - Robustness test

Setup

- ▶ 13 geometries from 1.1.
- ▶ 6 refinement sizes: $N_{max} = 14 \cdot 2^{0:5}$

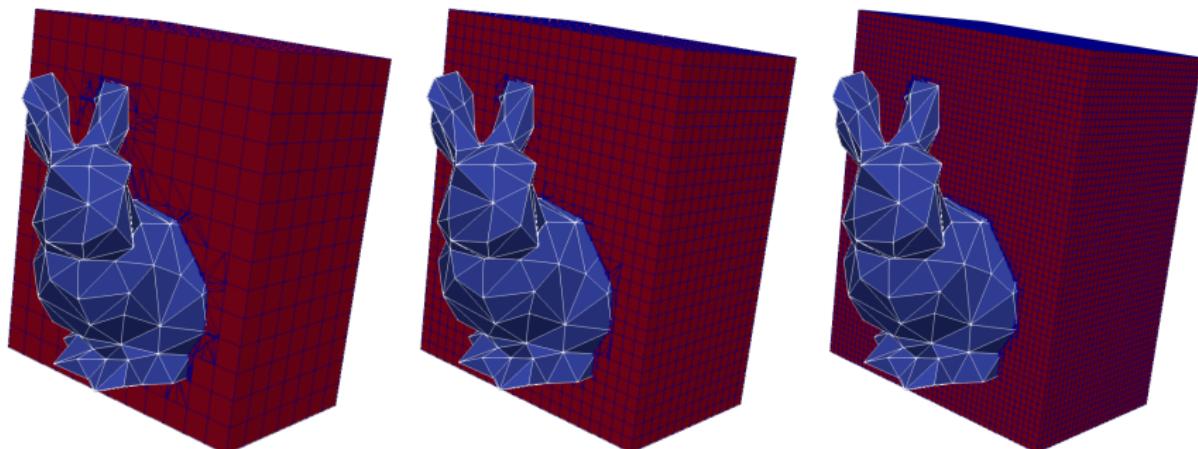


NOTE 1: The N_{max} is multiple of 14 to force the STL faces and background cell faces to be aligned, thus stress more the algorithm. As the background mesh is expanded 0.2 in each direction of the STL's bounding box.

2.1. h -refinement - Robustness test

Setup

- ▶ 13 geometries from 1.1.
- ▶ 6 refinement sizes: $N_{max} = 14 \cdot 2^{0:5}$

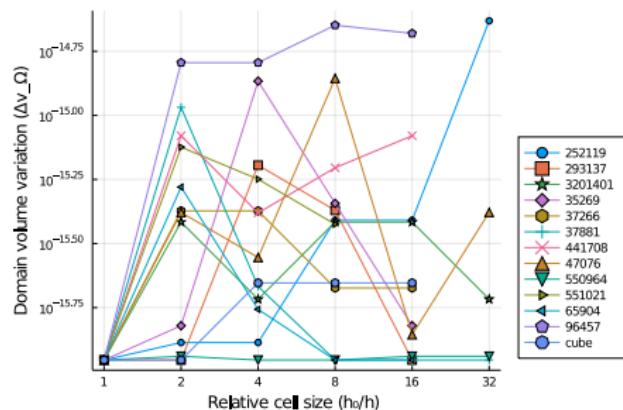
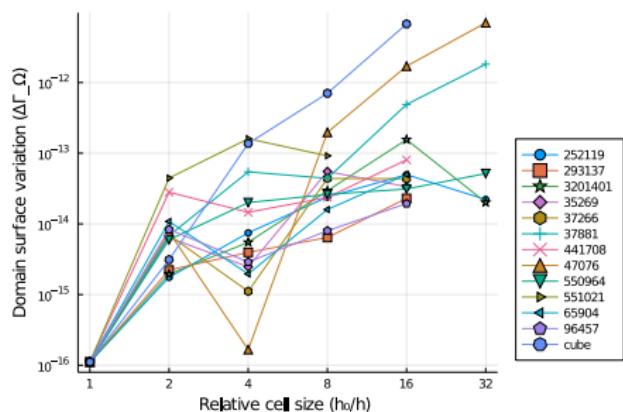


NOTE 2: In order to keep the background cell aspect ratio, N_{max} is the number of divisions on the largest side of the bounding box.

2.1. h -refinement - Robustness test

h -refinement

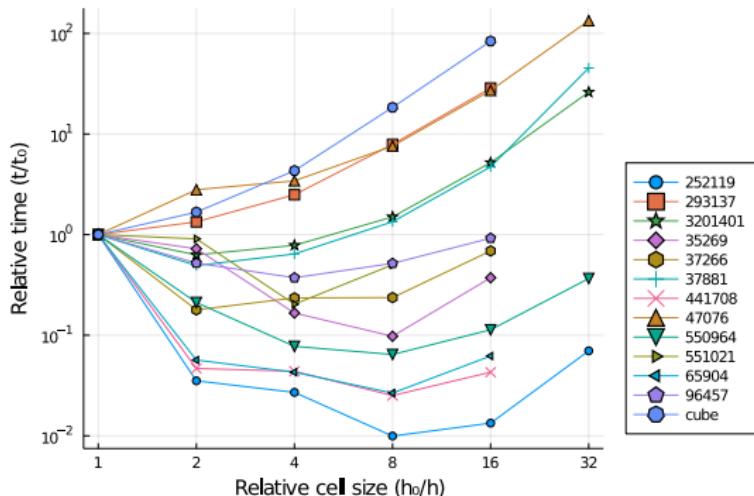
- Surface variation increases with $1/h$ ($\Delta\Gamma < 10^{-11}$)
- Volume is constant at refinement ($\Delta V < 10^{-14}$)



Robustness matrix

CPU time with h -refinement

- Not precise measure (single runs)
- Tend to be linear after first complexity reduction



Large geometry dataset

Setup

- ▶ 5052 geometries filtered from Thingi10k
- ▶ $N_{max} = 100$ (unique h -refinement criterion)

Thingi 10k dataset

Summary

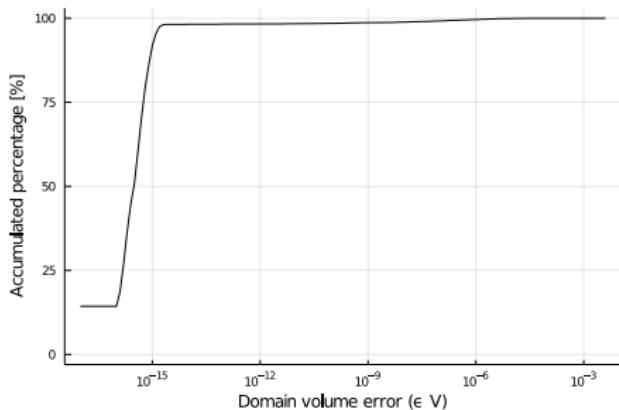
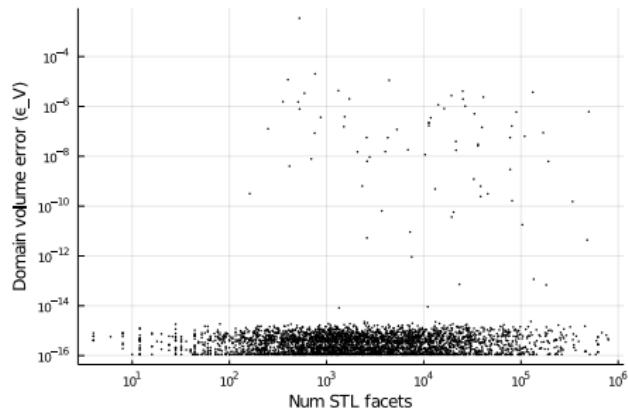
```
Total = 5052
  └── Not available: 312
  └── Load error: 7
  └── Available: 4733
      └── Launched on HPC: 4072
          └── Success: 3986
          └── Large volume error: 53
          └── Not ended: 33
      └── Pending: 661
```

NOTE: As shown in next slides large volume error is due to small facets.

Thingi 10k dataset

Volume error

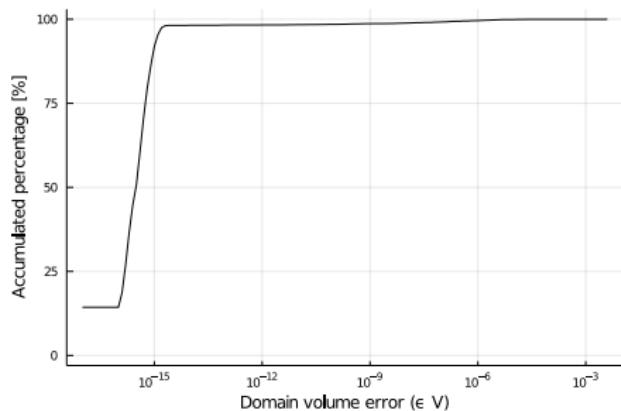
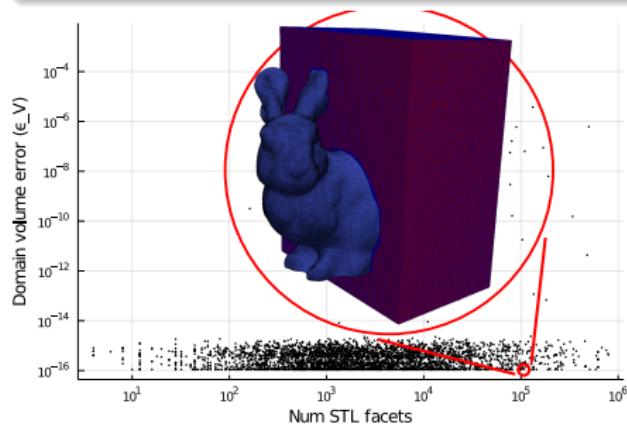
- ▶ $\epsilon_V = V_{IN} + V_{OUT} - V_{BBOX}$
- ▶ 98.7% of 4039 is below 10^{-9}
- ▶ All STLs above 10^{-9} contain small facets



Thingi 10k dataset

Volume error

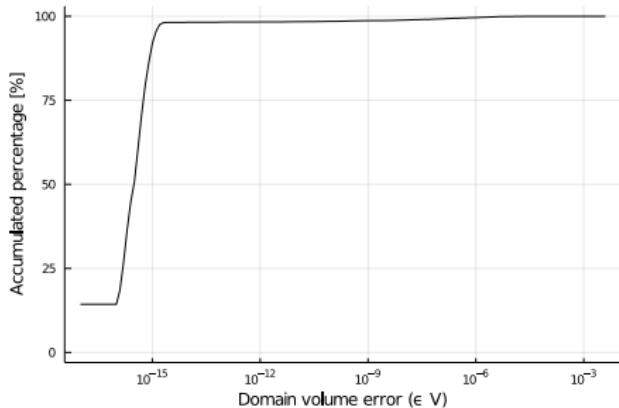
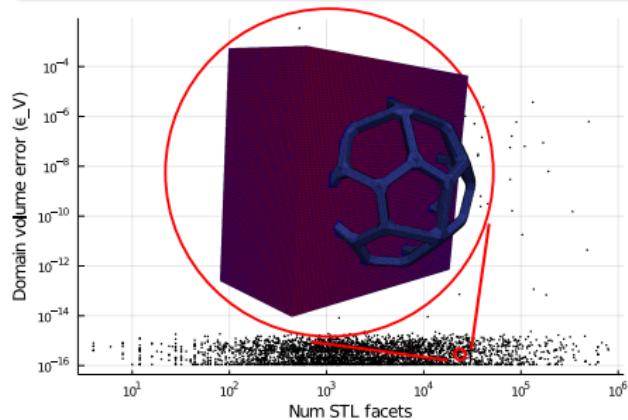
- ▶ $\epsilon_V = V_{IN} + V_{OUT} - V_{BBOX}$
- ▶ 98.7% of 4039 is below 10^{-9}
- ▶ All STLs above 10^{-9} contain small facets



Thingi 10k dataset

Volume error

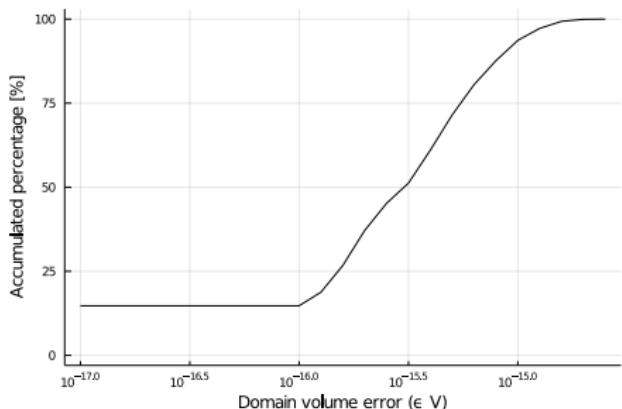
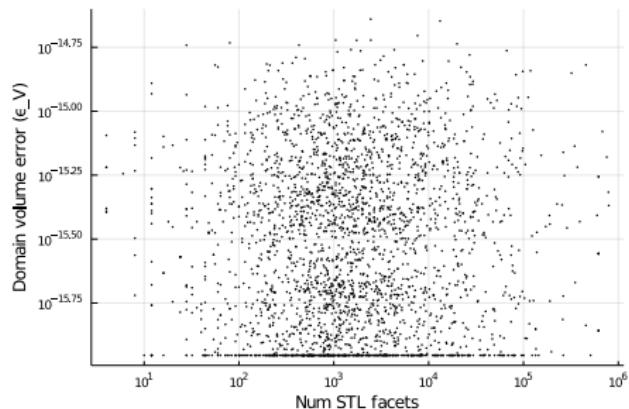
- ▶ $\epsilon_V = V_{IN} + V_{OUT} - V_{BBOX}$
- ▶ 98.7% of 4039 is below 10^{-9}
- ▶ All STLs above 10^{-9} contain small facets



Thingi 10k dataset

Volume error [filtering STLs with small facets]

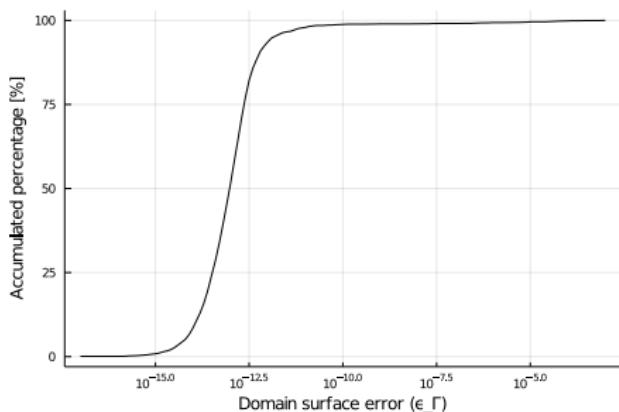
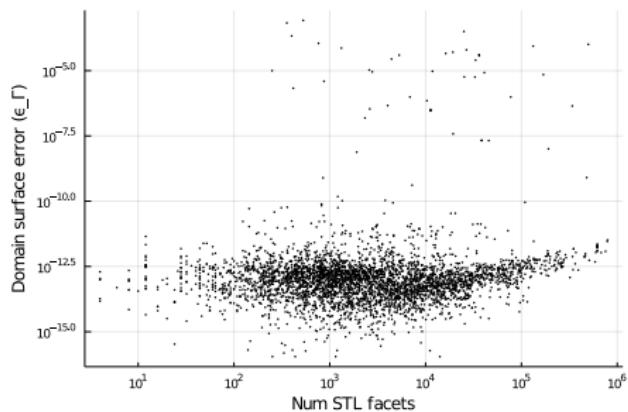
- $\epsilon_V = V_{IN} + V_{OUT} - V_{BBOX}$
- 100% is below 10^{-14}



Thingi 10k dataset

Surface error

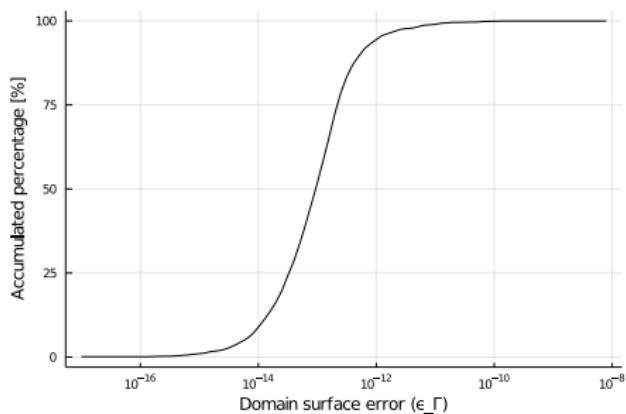
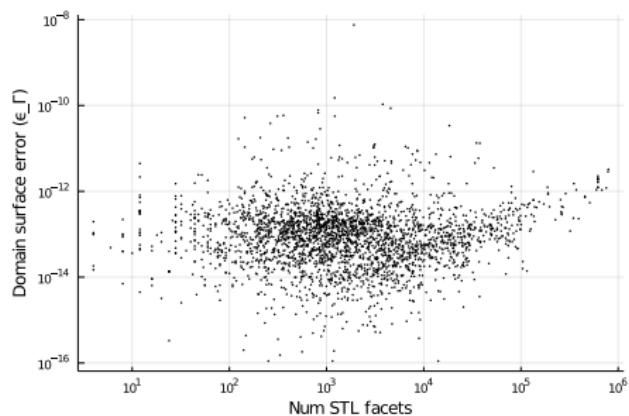
- ▶ $\epsilon_{\Gamma} = \Gamma - V_{STL}$
- ▶ 99.0% of 4039 is below 10^{-9}
- ▶ (almost) All STLs above 10^{-9} contain small facets



Thingi 10k dataset

Surface error [filtering STLs with small facets]

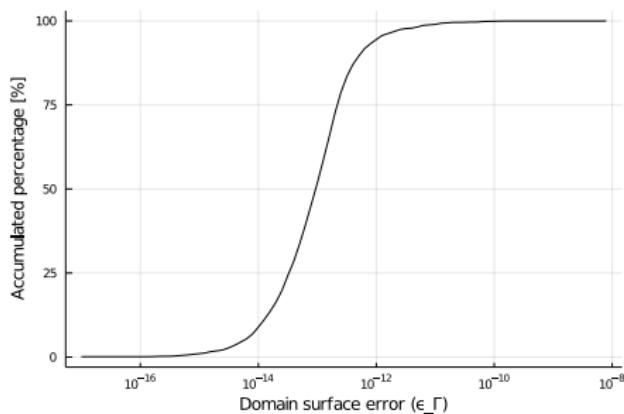
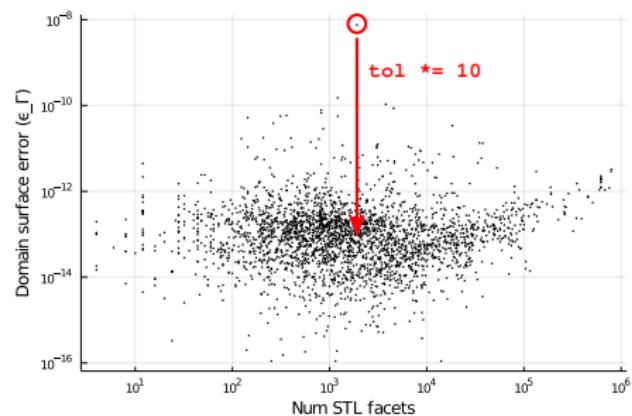
- ▶ $\epsilon_{\Gamma} = \Gamma - V_{STL}$
- ▶ 99.9% is below 10^{-9}
- ▶ One outlier can be moved by increasing the tolerance



Thingi 10k dataset

Surface error [filtering STLs with small facets]

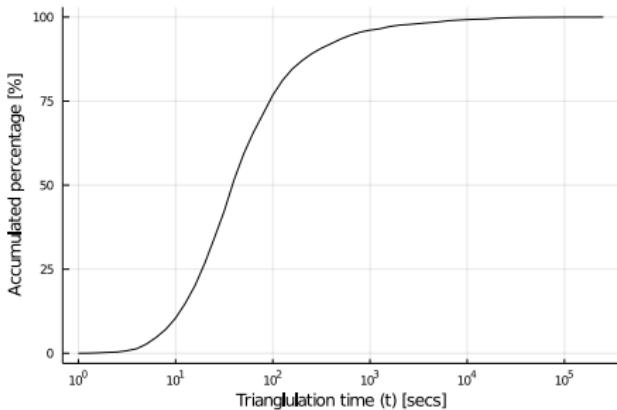
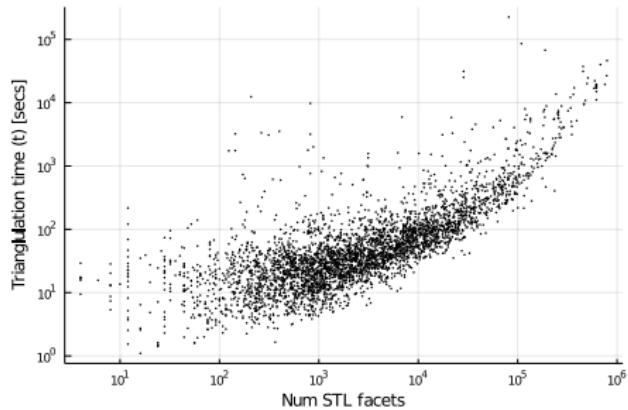
- $\epsilon_{\Gamma} = \Gamma - V_{STL}$
- 99.9% is below 10^{-9}
- One outlier can be moved by increasing the tolerance



Thingi 10k dataset

CPU time

- ▶ Not precise measure (different machines, single runs)
- ▶ Increasing with the number of STL facets



Robustness matrix

Summary

100% of ended test have volume and surface error bounded
 $(\epsilon_{vol} < 10^{-14}, \epsilon_{surf} < 10^{-12})$

The mesh sizes have n_{max} multiple of 14 as the bounding box is expanded a factor 0.2 in each direction, thus the domain is 1.4 times the bounding box per axis. The background cells will match the STL bounding box, stressing even more the algorithm.

NOTE: Due to large computational requirements (time/memory), some tests have not ended. Those points are missing at the lowest and largest sizes.

- ▶ Low n_{max} : large amount of STL facets per cell
- ▶ High n_{max} : large background mesh

Conclusions and pending work

Conclusion so far

- ▶ Issues are depending on the geometry
- ▶ Most of problematic geometries can be found *a priori*

Ongoing work

- ▶ Detect true degenerated geometries
- ▶ Run Gridap