Volume mesh generation using a level set method

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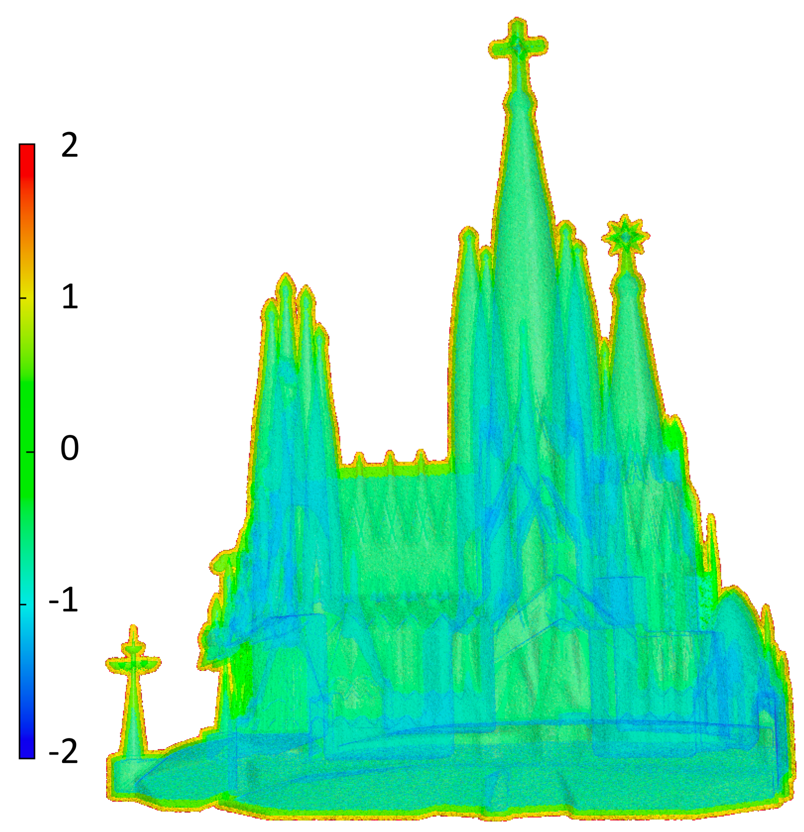
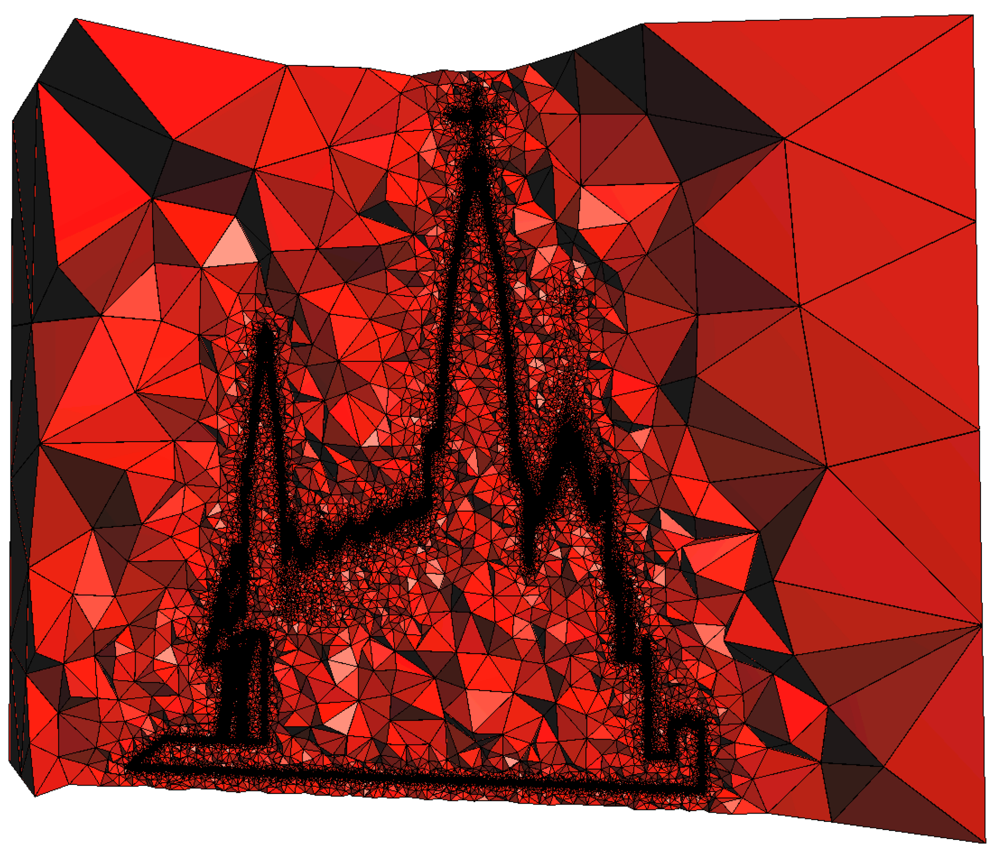
- **Target:** automatic mesh generation from an arbitrary surface (non-conforming, analytical…) for computational fluid dynamics, stress computation or visualization

Steps 1 & 2: Computation of the signed distance function to a discrete contour on an arbitrary tetrahedral mesh and Isotropic level-set adaptation (few iterations of this 2 steps)



Signed distance isosurfaces on the last mesh (after 4 iter. of adaptation)
mshdist software



Last adapted mesh (4th iter)
metric computation: mshmet software
mesh adaptation: Mmg platform

4th iteration (1h20)

Input mesh

#Nodes	9m
#Elements	51m

Output mesh

#Nodes	26m
#Elements	153m

Qualities*:
- Wrst. 0.2
- Stats. 99% > 0.5

Lengths***:
- Size min. 0.0009
- Ratio max : 2.
- Metric agreement: 0.7 < 95% < 1.4

Formulae

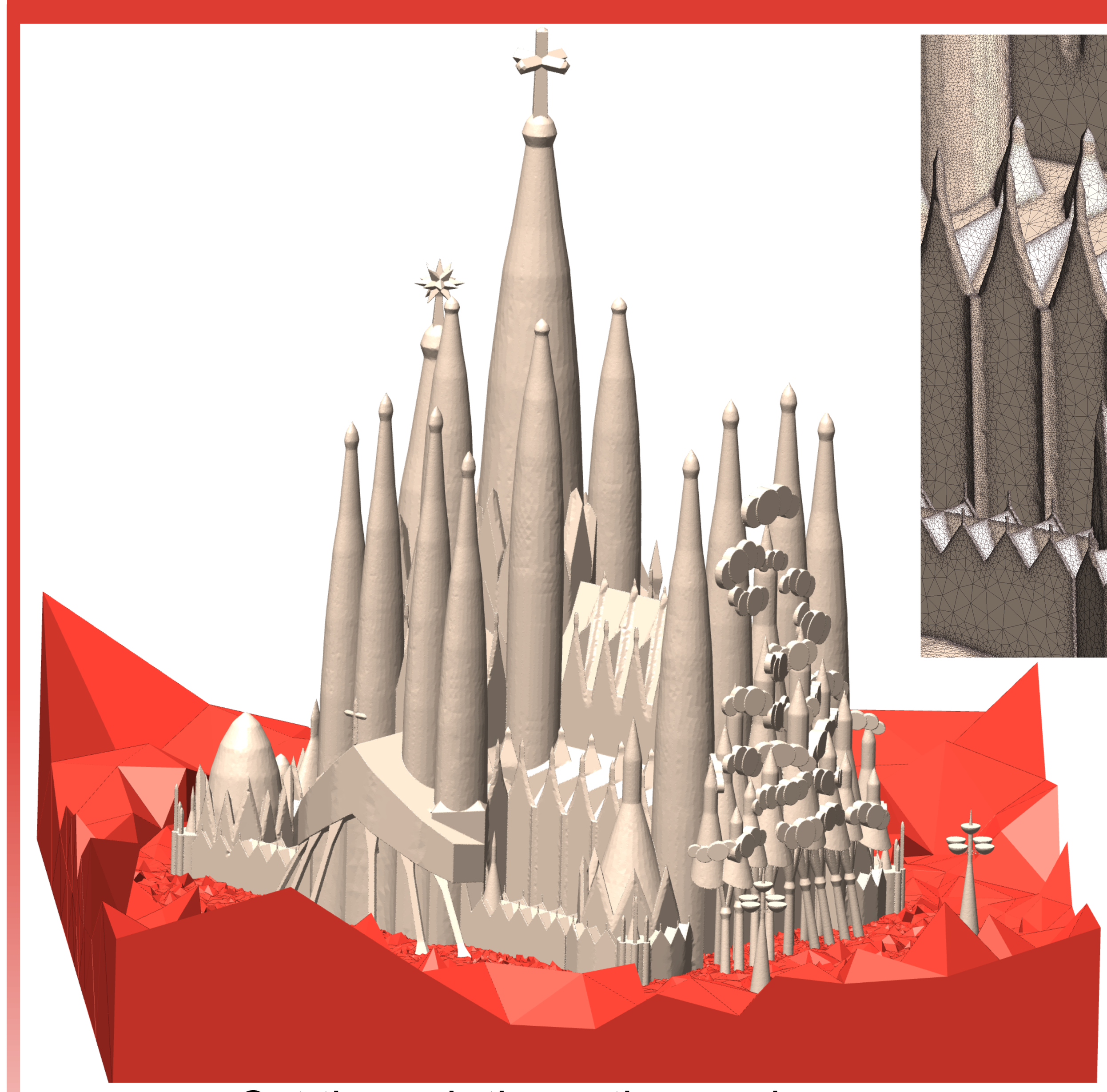
*Tetra. quality: $Q = \alpha_1 \frac{V}{\bar{l}^3}$

**Tria. quality: $Q_s = \alpha_2 \frac{S}{\bar{l}^2}$

***Edge length: $l_{AB} = \frac{\| AB \|}{h_a - h_b} ln(\frac{h_b}{h_a})$

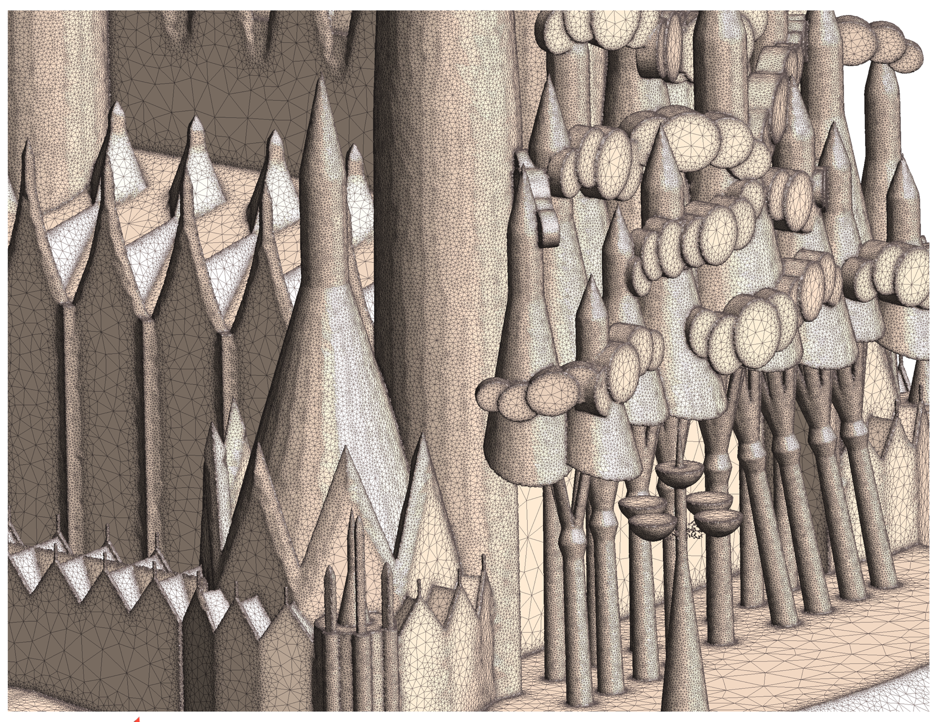
α : normalization factor
V : tetrahedron volume
S : triangle area
$\bar{l}$: mean edge length
h : prescribed size

Step 3: Level set discretization



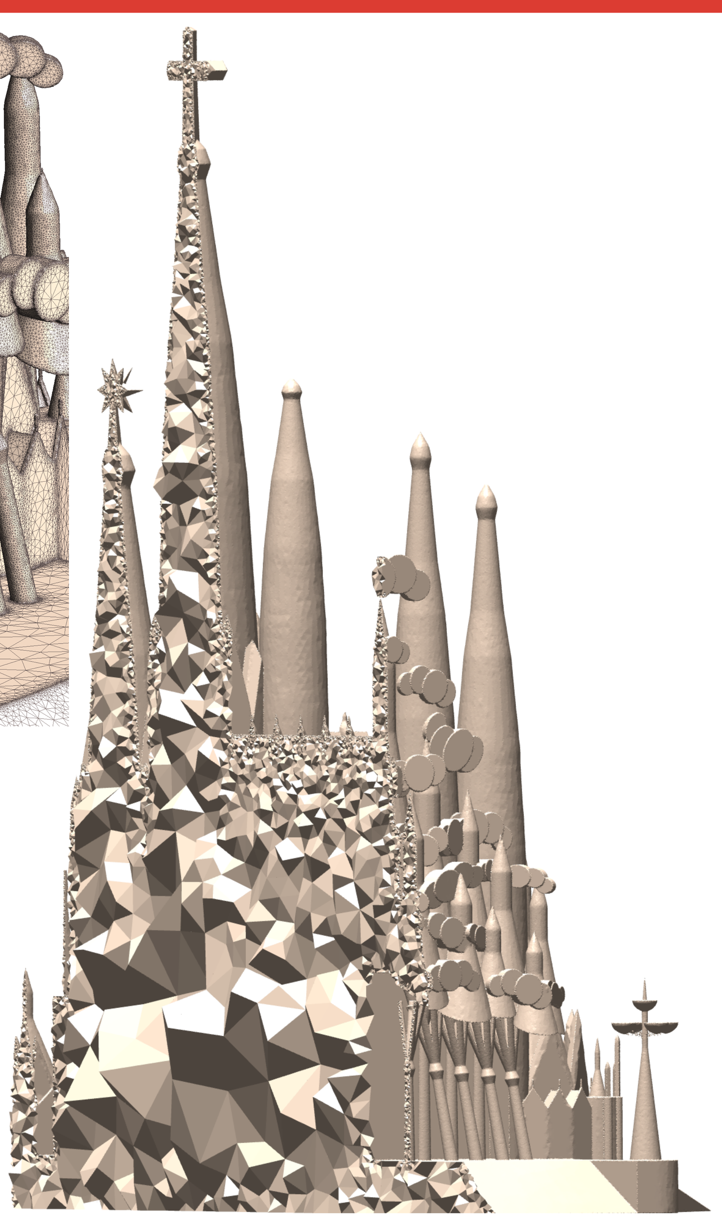
Cut through the entire mesh

#Nodes	10m	Qual.*	95% > 0.5
#Elements	60m	Min edge length	0.0001
		Edge ratio max.	2.



Surface mesh

#Nodes	3m
#Triangles	6m
Qual.**	99.9% > 0.5



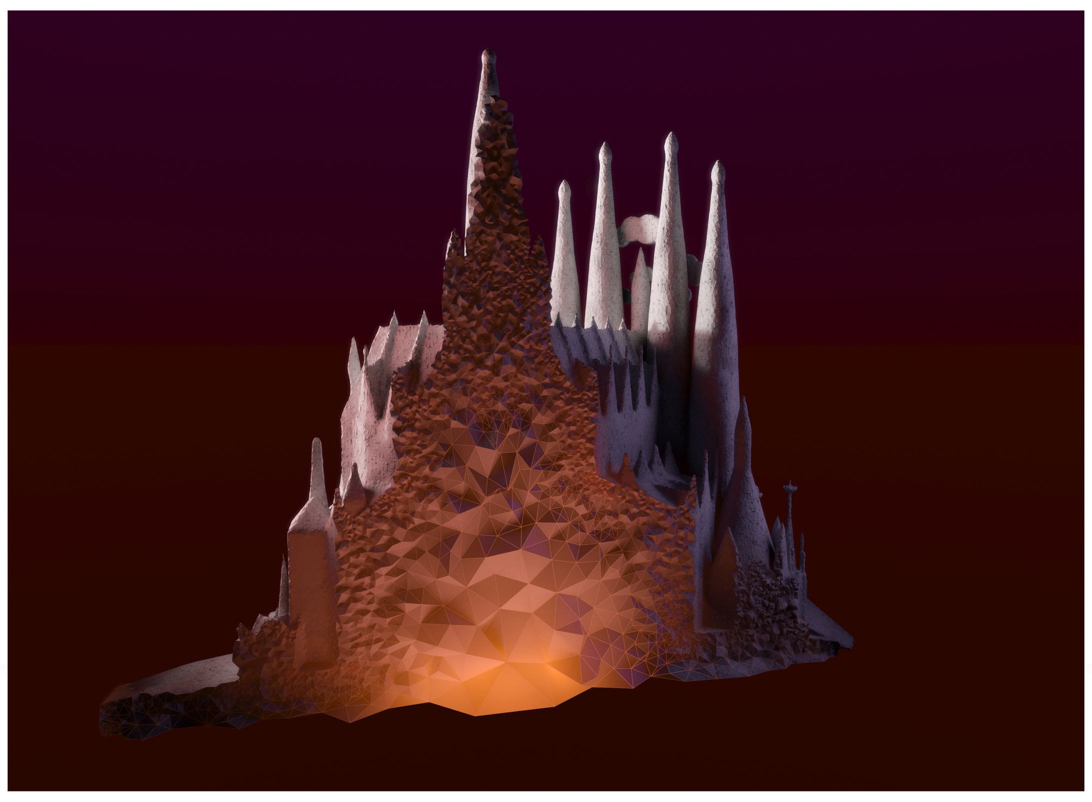
Cut through the internal volume mesh

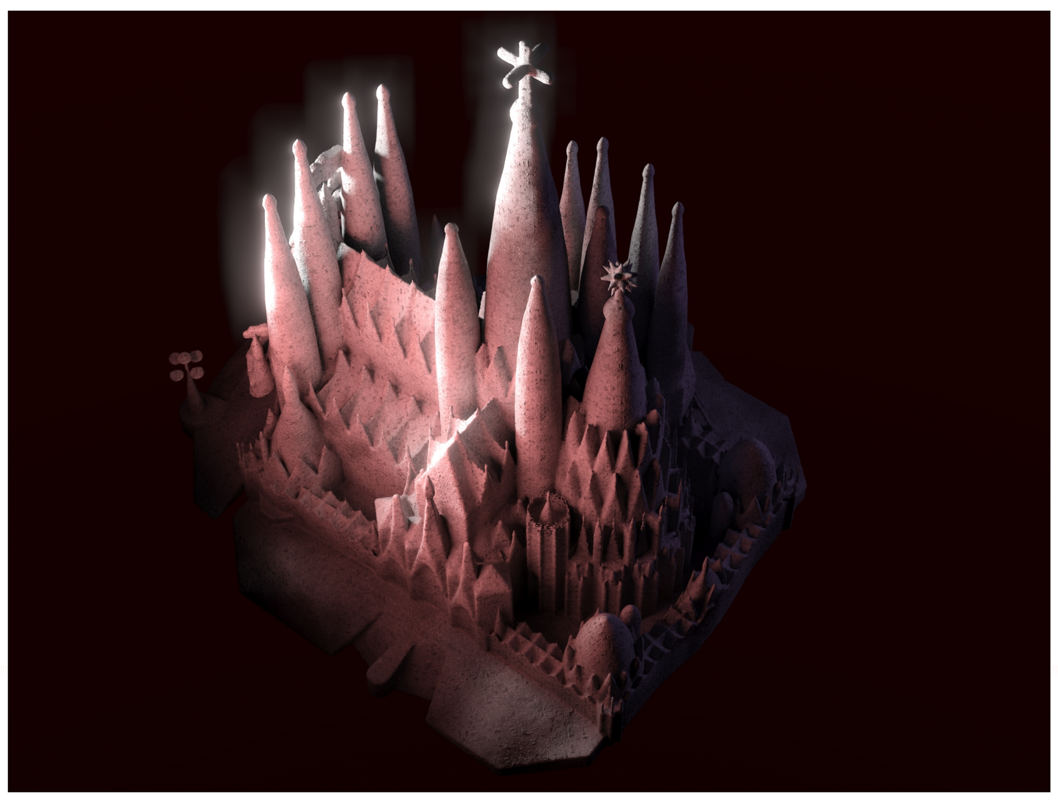
#Nodes	6m
#Elements	28m
Qual.*	95% > 0.5

Cut through the embedding volume mesh

#Nodes	4m
#Elements	31m
Qual.*	95% > 0.5

Application example: visualization (thanks to S. Le Gall)





Conclusion

Advantages of the method:
- Genericity: a computational mesh of a domain can be generated from the datum of its distance function only (which can be obtained from an unorganized point cloud, a non-conforming surface…)
- We obtain a volume mesh of the inside and the outside of the discretized isovalue. Both may be used for various applications.

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Mmg PLATFORM Robust, Open-source & Multidisciplinary Software for Remeshing

Upgrade your meshes