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Automatic construction of a parametric domain for the adaptive Meccano triangulation of objects with genus-zero surfaces

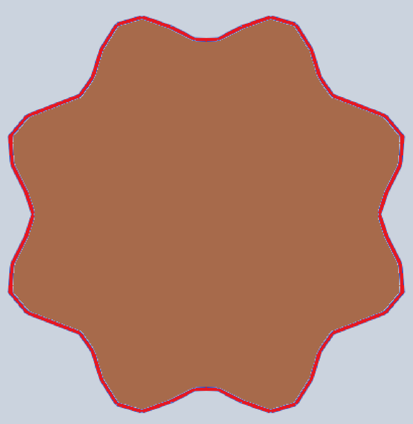
Guillermo V. Socorro-Marrero[1], A. Oliver[1], R. Montenegro[1]

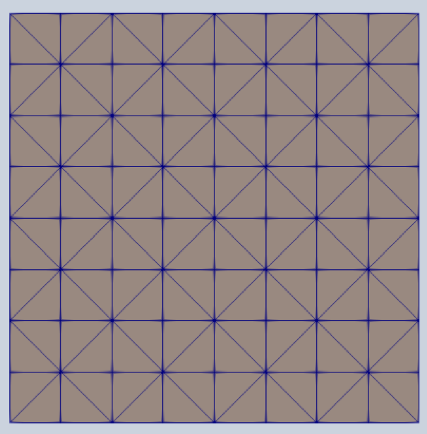
[1]University Institute for Intelligent Systems and Numerical Applications in Engineering, Universidad de Las Palmas de Gran Canaria

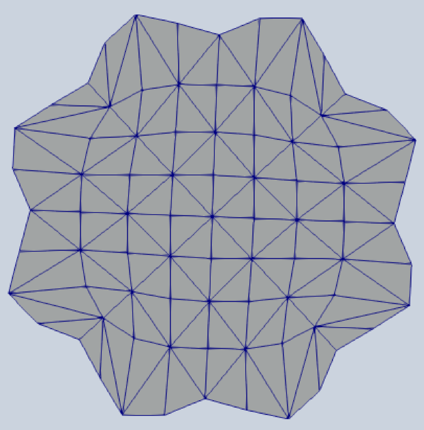
The Meccano method

The Meccano method [1] provides simultaneously an adaptive mesh of triangles and a surface parameterization. It includes the following steps:

- Selection of the parametric domain (meccano) by the user (or the default rectangle).
- Parameterization of the physical boundary on the parametric one
- Kossaczký refinement [2] of the triangular mesh in the parametric domain
- Projection of boundary parametric nodes to their corresponding physical location attending to the boundary parameterization.
- Simultaneous untangling and smoothing of the mesh (to relocate inner nodes and improve cell quality.

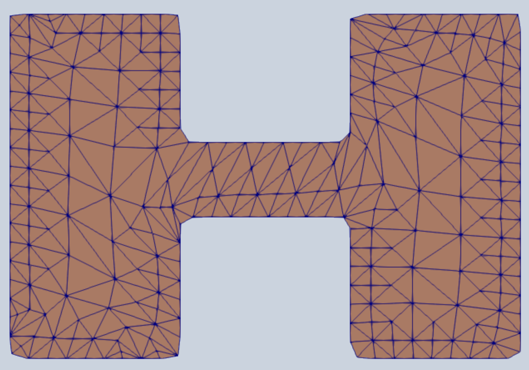

Original surface


Parametric domain (meccano)


Physical domain

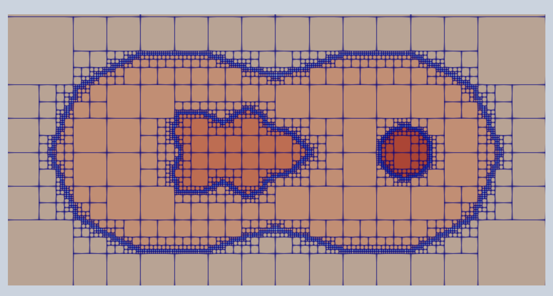
Motivation of the work

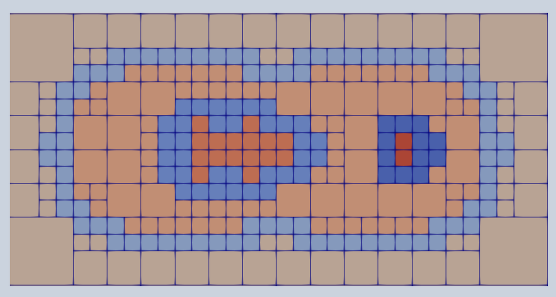
In the case that the boundary in the parametric domain (the contour of the square) does not properly approximate the boundary of the physical domain, low quality elements could appear and neither the refinement nor the mesh optimization could reduce the distortion. In this work we propose an innovative strategy to obtain a suitable selection of the parametric domain in order to prevent this troublesome situation.

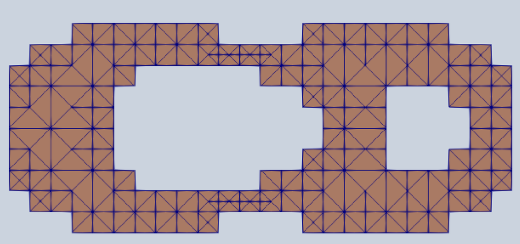

High distortion in a bottleneck-like shape surface

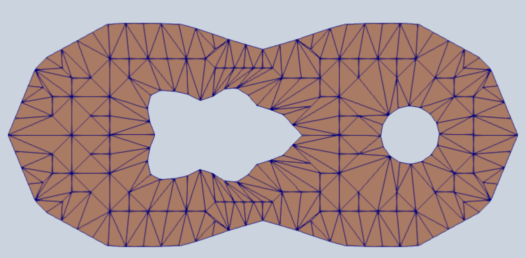
Steps of the proposed solution

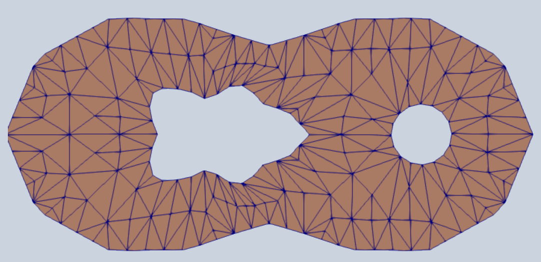
The original algorithm has been modified and now includes the following steps:

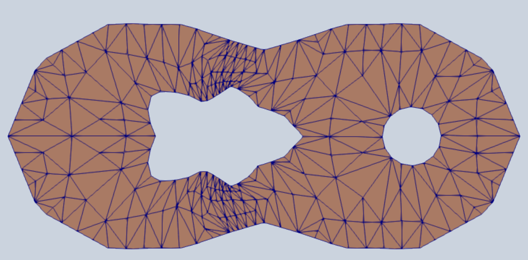

1. Fine quadtree approximation of topology


2.. Coarse quadtree approximation of topology


3. Parametric domain (meccano)


4. Projection of boundary nodes

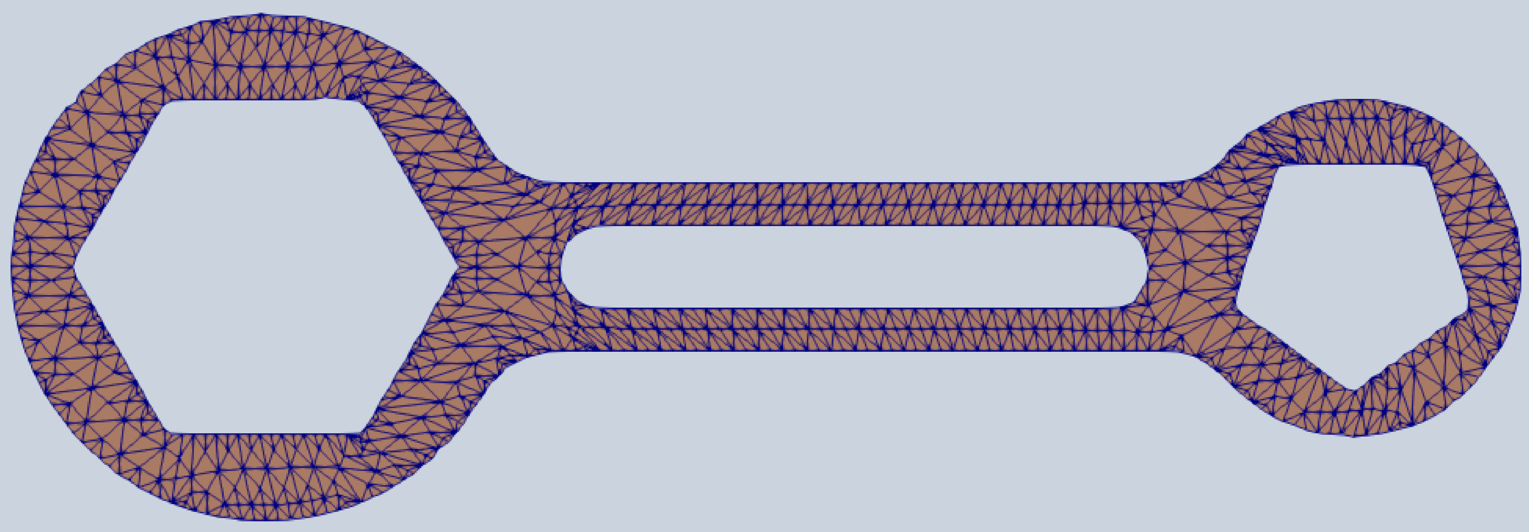

5. Relocation of inner nodes (smoothing)


6. Final adaptive mesh

Experimental results

Quality statistics

	min quality	mean quality	max quality
Wrench	0.240	0.781	0.999


Adaptive mesh for a complex geometry: custom wrench

Conclusions

The described technique automatically provides a coarse parametric domain, suitable as meccano for the proposed mesh generator and less prone to element degeneration than the default rectangular parametric domain. The main advantages of the proposed algorithm are:

- Totally automatic setup of the mesh generator (no user intervention is needed).
- Low distortion between parametric and physical domains
- Robustness and higher cell qualities.

Forthcoming Research

- Improve the coarse quadtree refinement in order to reduce the initial number of nodes
- Include the smoothing for boundary nodes.

References

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2 I. Kossaczký, A recursive approach to local mesh refinement in two and three dimensions. Journal of Computational and Applied Mathematics, Nov. 1994.

3 E. Ruiz-Gironés, A. Oliver, G. V. Socorro-Marrero, J. M. Cascón, J. M. Escobar, R. Montenegro, and J. Sarrate, Insertion of triangulated surfaces into a meccano tetrahedral discretization by means of mesh refinement and optimization procedures. International Journal for Numerical Methods in Engineering, Nov. 2017.

Acknowledgements

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Contact information

- Guillermo V. Socorro-Marrero. Email: gvsocorro@siani.es. Tel.: +34 928451923.