Toward automatic block decomposition of 3D models by exploiting frame fields

Maxence Reberol[†*], Alexandre Chemin[†] and Jean-François Remacle[†]

[†] UCLouvain
1348 Louvain-la-Neuve, Belgium
[*] e-mail: maxence.reberol@uclouvain.be

ABSTRACT

CAD softwares usually produce boundary representations of 3D models (B-Rep) whereas most numerical simulation techniques rely on volume representations (V-Rep). The ideal volume representation for simulation is a block decomposition made of coarse hexahedra (6-face block) as they can be easily parametrized by tri-variate functions or decomposed into block-structured hexahedral meshes.

Unfortunately, generating a block decomposition from a boundary representation is a hard problem because of topological constraints inherent to the 6-faced blocks. One infamous example is the Schneider pyramid (one quadrilateral and three triangular faces) for which the best known decomposition is made of 36 hexahedra with very poor element qualities [1].

An essential characterization of a block decomposition is its singular skeleton: a set of edges whose hexahedral valence is different from four in the interior and different from two on the boundary. In the last decade, new hexahedral meshing based on boundary-aligned 3D frame fields [2] have been investigated because these fields have a topological structure very similar to hexahedral meshes. In some cases, they contain singular curves that are a one-to-one match with the skeleton of a block decomposition [3]. But there is no guarantee and often 3D frame fields do not match with a block decomposition [4].

Non-decomposable frame fields are often caused by certain boundary conditions during the frame field design step. We propose new internal conditions to avoid these issues and show how it allows us to deal with a broader range of CAD models. Once a decomposable frame field is generated, we explore various ways to build a valid block decomposition suitable for numerical analysis.

REFERENCES

[1] Verhetsel K., Pellerin J. and Remacle J.F., Finding Hexahedrizations for Small Quadrangulations of the Sphere, 2019, arXiv:1904.11229

[2] Huang, J., Tong, Y., Wei, H., and Bao, H., Boundary aligned smooth 3D cross-frame field. *ACM Transactions on graphics (TOG)*, 2011

[3] Kowalski, N., F. Ledoux, and P. Frey. Block-structured hexahedral meshes for CAD models using 3d frame fields. *Procedia Engineering 82*, 2014

[4] Viertel, R., Staten, M. L., and Ledoux, F., Analysis of Non-Meshable Automatically Generated Frame Fields. *International Meshing Roundtable*, 2016