The 8th European Congress on Computational Methods in Applied Sciences and Engineering
ECCOMAS Congress 2022
5-9 June 2022, Oslo, Norway

P^2 cavity operator with simplex-based Jacobian correction and metric-based volume edge curvature

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Keywords: *Metric-based anisotropic mesh adaptation, High-order meshing, Polynomial Bézier elements, P^2 cavity operator*

In this talk, we present a Bézier tetrahedron Jacobian correction procedure based on the simplex algorithm for linear programs. The Jacobian determinant J_K of a degree d tetrahedron is a degree $3(d-1)$ polynomial of the barycentric coordinates but always a degree 3 polynomial of the control points and vertices. However, no cubic terms of the same geometric (control points and vertices) variable exist, due to its nature as a sum of determinants of vertex and control point columns. Therefore, when isolating a single vertex or control point, J_K can be seen as an affine function whose coefficients depend on the other vertices and control points, as well as the barycentric coordinates. Using its representation as a sum of Bernstein polynomials at the barycentric coordinates pondered by the so-called control coefficients $(N_i)_i$ — that depend only on the vertices and control points —, a conservative lower bound of J_K can be obtained from the minimum of the scalars N_i. Since these N_i inherit the polynomial structure of J_K with regards to element geometry, they remain linear with regards to any given control point and the problem

$$\max_{X \in \mathbb{R}^3} \min_i N_i(X)$$

is a linear program (when put in constraint form) that can be solved very efficiently using the simplex algorithm.

The integration of this optimization procedure into our P^2 cavity operator [1] will then be discussed, as well as some early results on the definition of a P^2 unit element stemming from error estimates on curved elements and how these may be used to propose better initial edges in the new cavity.

REFERENCES

[1] Lucien Rochery and Adrien Loseille. P2 Cavity Operator with Metric-Based Volume and Surface Curvature. In *29th International Meshing Roundtable*, 2021.