Computational complexity of isogeometric FEM with T-splines and B-splines over 2D h-refined grids

Pawel Lipski[1], Bartosz Janota[1*], Maciej Paszynski[1], Victor Calo[2]

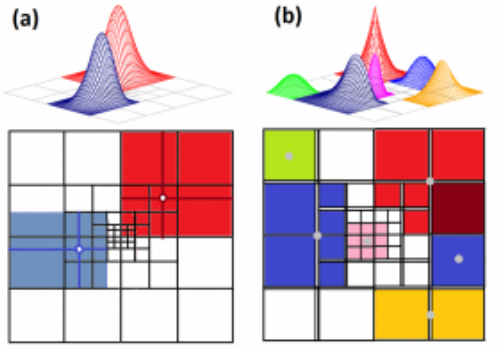
[1]AGH University of Science and Technology
Krakow, Poland
pawel.p.lipski@gmail.com, bartosz.janota@gmail.com, paszynsk@agh.edu.pl

[2]The University of Western Australia
Perth, Australia
vmcalo@gmail.com

ABSTRACT

In the paper we compare two different strategies (as shown in the figure) for dealing with local singularities in two-dimensional isogeometric finite element method.
The first strategy (left panel of the figure) are grid h-refinements with T-splines [1]. The second strategy (right panel) is our own B-spline based solution ([2]) utilizing repeated knots, so that local mesh irregularities are separated by C^0 borders. The criterion for comparison is the computational cost of the multi-frontal direct solver MUMPS [3,4].
For 2D point singularity and T-splines (1st strategy) we obtain O(N^2.95), for the 2nd strategy we obtain O(N^1.37). The corresponding complexities for edge singularities are: 1st strategy - O(N^2.95), 2nd strategy - O(N^1.38). The reason for high computational cost of T-spline strategy is that the basis functions overlap at several layers around the singularity. The B-spline strategy decouples the basis functions so they overlap at as few layers as possible, and thus the computational complexity is reduced to almost linear.

The work is supported by National Science Center (Poland), grant no. DEC-2012/07/B/ST6/01229.



References

[1] Y. Bazilevs, V.M. Calo, J.A. Cottrell, J.A. Evans, S. Lipton, M.A. Scott, T.W. Sederberg, “Isogeometric analysis using T-splines.” Computer Methods in Applied Mechanics and Engineering, 199 (2010) 229-263.
[2] T.J.R. Hughes, J.A. Cottrell, Y. Bazilevs, Isogeometric analysis: CAD, finite elements, NURBS, exact geometry and mesh refinement, Computer methods in applied mechanics and engineering 194(39) (2005) 4135-4195.
[3] P. R. Amestoy, I. S. Duff, J. Koster and J.-Y. L'Excellent, A fully asynchronous multifrontal solver using distributed dynamic scheduling, SIAM Journal of Matrix Analysis and Applications, 23(1) (2001) 15-41.
[4] P. R. Amestoy, A. Guermouche, J.-Y. L'Excellent and S. Pralet, Hybrid scheduling for the parallel solution of linear systems. Parallel Computing Vol 32 (2) (2006) 136-156.