Computationally efficient Isogeometric Analysis

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ABSTRACT

This work is in collaboration with Mattia Tani and Francesco Calabrò

The isogeometric k-method, based on high-degree high-regularity splines or NURBS, delivers higher accuracy per degree-of-freedom in comparison to C^0 finite elements. However, the computational cost per degree-of-freedom is higher for smooth splines in a code that uses standard finite element routines. The higher computational cost is due to the higher cost of the formation of the system matrix and the higher cost of the solution of the linear system. This presentation is about promising approaches towards computationally-efficient k-method, from the papers [1] and [2].

In [1], in collaboration with Francesco Calabrò and Mattia Tani, we propose an algorithm for the formation of matrices of isogeometric Galerkin methods. The algorithm is based on a loop on the rows of the matrix and on the calculation of the row entries by weighted quadrature. The test function is incorporated in the integration weight while the trial function, the geometry parametrization and the PDEs coefficients form the integrand function. This approach is very effective in reducing the computational cost, while keeping the optimal order of approximation of the method. The analysis of the costs is confirmed by the numerical testing, where we show that surprisingly, for degree p large enough, the time required by the floating point operations is even less than the time spent in the unavoidable memory operations (the sparse matrix allocation and memory write). The approach is well suited for a matrix-free and parallel implementation

In [2], Mattia Tani and myself consider the linear systems arising from the isogeometric discretization of the Poisson problem. We consider a preconditioning strategy which is based on the solution of a Sylvester-like equation at each step of an iterative solver. We show that this strategy, which fully exploits the tensor structure that underlies isogeometric problems, is robust with respect to both mesh-size h and spline degree p.

REFERENCES

[1] F. Calabrò, G. Sangalli, and M. Tani. Fast formation of isogeometric Galerkin matrices by weighted quadrature. *CMAME* , Volume 316, 1 April 2017, Pages 606622; *ArXiv e-print n.1605.01238*, May 2016.

[2] G. Sangalli and M. Tani. Isogeometric preconditioners based on fast solvers for the Sylvester equation. SIAM J. Sci. Comput., 38(6), Pages A3644A3671. . *ArXiv e-print 1602.01636*, February 2016.