Partial tensor decomposition for decoupling isogeometric Galerkin discretizations

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PII: S0045-7825(18)30150-6
DOI: https://doi.org/10.1016/j.cma.2018.03.026
Reference: CMA 11832

To appear in: *Comput. Methods Appl. Mech. Engrg.*

Received date : 14 December 2017
Revised date : 15 March 2018
Accepted date : 16 March 2018

Please cite this article as: F. Scholz, A. Mantzaflaris, B. Jüttler, Partial tensor decomposition for decoupling isogeometric Galerkin discretizations, *Comput. Methods Appl. Mech. Engrg.* (2018), https://doi.org/10.1016/j.cma.2018.03.026

Partial tensor decomposition for decoupling isogeometric Galerkin discretizations

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Abstract

System matrix assembly for isogeometric (i.e., spline-based) discretizations of partial differential equations is more challenging than for classical finite elements, due to the increased polynomial degrees and the larger (and hence more overlapping) supports of the basis functions. The global tensor-product structure of the discrete spaces employed in isogeometric analysis can be exploited to accelerate the computations, using sum factorization, precomputed look-up tables, and tensor decomposition. We generalize the third approach by considering partial tensor decompositions. We show that the resulting new method preserves the global discretization error and that its computational complexity compares favorably to the existing approaches. Moreover, the numerical realization simplifies considerably since it relies on standard techniques from numerical linear algebra.

Keywords: isogeometric analysis, tensor decomposition, numerical integration, low-rank approximation, matrix assembly, singular value decomposition

1. Introduction

Isogeometric discretizations (see [1]) possess significant advantages for the numerical solution of partial differential equations (PDEs). These include the higher smoothness of the obtained numerical solution (when using higher polynomial degree), the compatibility of the representation with models coming from computer-aided design (CAD) systems, as well as the reduction of the number of degrees of freedom required to reach a prescribed accuracy level. However, these advantages come at the price of increased computation costs per degree of freedom, and this effect becomes even more pronounced as the dimension increases [2]. The computational efficiency challenges manifest themselves both

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