Partial Tensor Decomposition for Decoupling Isogeometric Discretisations

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In isogeometric analysis, tensor decomposition methods can be applied to overcome the computational difficulties when performing the quadrature for assembling the system matrix. Unlike the discretisations used in finite element methods, the spline discretisations employed in isogeometric analysis possess a global tensor product structure which can be used in several ways to reduce the complexity of the quadrature. The exploitation of this tensor product structure enables us to deal with the computational disadvantages stemming from the increased polynomial degrees and the larger support of the basis functions

In the present work we introduce a partial tensor decomposition based on singular value decomposition which is applied to the integrands' coefficient tensors in an isogeometric discretisation, thereby replacing the trivariate or fourvariate quadrature by the evaluation of a number of lower-variate integrals. In three dimensions, the method achieves quasi-optimal computational complexity for the assembly of the system matrices and outperforms the assembly method obtained by using a full tensor decomposition of the coefficient tensors. A natural application of this approach are four-dimensional space-time problems, making it possible to decouple the integration in space from the integration in time.

We analyse the computational complexity of the method and demonstrate its advantageous behaviour both theoretically and in the run-times of computationally demanding numerical experiments.

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