Reduced quadrature in IGA at superconvergent points for linear elasticity

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ABSTRACT

An efficient implementation of isogeometric analysis (IGA) plays an important rule in current research. Standard Gaussian quadrature rules are not well-suited for an application in IGA, since they do not consider the higher continuity of the shape functions. Therefore different quadrature strategies have been investigated. In addition collocation methods have gained attention, since they have shown to be competitive to Galerkin methods.

Recent improvements regarding the convergence rates of isogeometric collocation methods have been made in [1,2]. In theses approaches estimates of characteristic evaluation points, named Cauchy-Galerkin points, are used. Collocation at the Cauchy-Galerkin points can reproduce the Galerkin solution exactly, if specific conditions are met. The estimation of these points is based on superconvergence theory. A discrete space constructed by smooth and pointwise non-negative basis functions is required, therefore the approach is convenient for the basis functions typically applied in IGA.

To combine the advantages of the Galerkin and the collocation method, we explore the use of estimated Cauchy-Galerkin points as quadrature points. Instead of directly using the Galerkin variational formulation of the considered numerical problems, the formulation resulting from an integration by parts is used as a basis for the new quadrature rule. The chosen approach can be seen as an intermediate form between the Galerkin variational formulation and the direct evaluation of the strong form in collocation approaches. The potential of the method is demonstrated by several numerical examples.

REFERENCES

[1] H. Gomez and L. De Lorenzis. *The variational collocation method.* Computer Methods in Applied Mechanics and Engineering, 309:152-181, 2016.

[2] M. Montardini, G. Sangalli, and L. Tamellini. *Optimal-order isogeometric collocation at Galerkin superconvergent points.* Computer Methods in Applied Mechanics and Engineering, 316:741-757, 2017.