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Reduced quadrature strategies in isogeometric analysis

***D. Schillinger[1,2], M.J. Borden[2], J.A. Evans[2,3], R. Hiemstra[2], T.J.R. Hughes[2]**

[1]Department of Civil Engineering, University of Minnesota, USA.
[2]Institute for Computational Engineering and Sciences, The University of Texas at Austin, USA.
[3]Department of Aerospace Engineering Sciences, University of Colorado at Boulder, USA.

*Corresponding author: dominik@ices.utexas.edu

Quadrature rules that achieve accurate integration of system matrices with the smallest possible number of quadrature points are of fundamental importance for the efficiency of an analysis technology. In Galerkin-type formulations, element-wise full Gauss quadrature is optimal for standard finite elements, but sub-optimal for isogeometric analysis, since it ignores the inter-element continuity of its smooth basis functions. In the first part of this contribution, we will review some traditional reduced quadrature rules for quadrilateral and hexahedral elements. We will show that for low order splines these rules are able to significantly reduce the quadrature cost for Galerkin-type formulations while maintaining stability. In the second part, we will show that isogeometric collocation dramatically reduces the cost for formation and assembly of system matrices for higher order splines. We interpret isogeometric collocation as a special reduced quadrature rule that achieves the optimum of only one quadrature point per node. In the third part, we will talk about the application of concepts from *hp*-collocation to the integration of Bézier elements. The corresponding isogeometric scheme makes full use of Bézier extraction to restore smoothness, maintains optimal accuracy and is less expensive than isogeometric analysis based on Bézier extraction and full Gauss integration.

Keywords: Isogeometric analysis, reduced quadrature, Galerkin methods, collocation methods