Università degli Studi di Pavia

Dipartimento di Ingegneria Civile e Architettura

in collaboration with

Centro di Simulazione Numerica Avanzata – CeSNA

Istituto Universitario di Studi Superiori

SEMINAR

Isogeometric Collocation: Cost Comparison with Galerkin Methods and Extension to Adaptive Hierarchical NURBS Discretizations

Collocation is based on the discretization of the strong form of the underlying partial differential equations, which requires basis functions of sufficient order and smoothness. Consequently, the use of isogeometric analysis (IGA) for collocation suggests itself, since splines can be readily adjusted to any order in polynomial degree and continuity required by the differential operators. Furthermore, IGA basis functions can be generated for domains of arbitrary geometric and topological complexity, directly linked to and fully supported by CAGD technology. The major advantage of isogeometric collocation over Galerkin type IGA is the minimization of the computational effort for numerical quadrature. This exceptional property constitutes a tremendous potential in applications, where the efficiency and success of an analysis technology is directly related to the cost of quadrature, e.g. in explicit dynamics.

First, we consider simple benchmark problems in 2D and 3D and compare IGA Galerkin, IGA collocation and standard FEA from several points of view, e.g. matrix bandwidth, cost of matrix-vector products, cost of stiffness and residual forms and accuracy vs. degrees of freedom as well as accuracy vs. computational cost. We show that IGA collocation has the potential to tremendously increase the computational efficiency of isogeometric analysis. Second, we explore an adaptive isogeometric collocation method that is based on local hierarchical refinement of NURBS basis functions and collocation points derived from the corresponding multi-level Greville abscissae. We introduce the concept of weighted collocation that can be consistently developed from the weighted residual form and the two-scale relation of B-splines. Using weighted collocation in the transition regions between hierarchical levels, we are able to reliably handle coincident collocation points that naturally occur at a multi-level Greville abscissa. The resulting method combines the favorable properties of isogeometric collocation and hierarchical refinement in terms of computational efficiency, local adaptivity, robustness and straightforward implementation, which we illustrate by numerical examples in one, two and three dimensions.

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