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ENFORCING DOMAIN COUPLING & BOUNDARY CONSTRAINTS IN ISOGEOMETRIC METHODS

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Over the past few years isogeometric methods have emerged to be serious competitors in the various fields of numerical simulation, e.g., solid mechanics, fluid dynamics and various multi-physics problems. In comparison to established concepts based on finite elements, isogeometric methods have proven their superiority in many respects by a large number of benchmark problems and proofs-of-concepts, revealing an increased accuracy per degree-of-freedom and unique higher order approximation and continuity capabilities.

Within this context, the initial idea to bridge the gap between computer aided geometric design (CAGD) and finite element analysis (FEA) by supporting a more tightly connected interaction of design and analysis faces the challenge of a simple and flexible model generation for complex industry-relevant problems, often assembled from numerous trimmed and non-conforming NURBS patches. The inherent need for multi-domain coupling in isogeometric methods has been addressed in a number of researches following several concepts adapted from, and often extending, domain decomposition methods developed in the framework of large-scale finite element simulations [1, 2]. Considering the coupling of domains as a problem of mutually depending essential boundary condition problems, in general, allows the use of the same conceptual approach for a reliable enforcement of constraints of both problems [3, 2]. Besides a strong enforcement of boundary condition and coupling constraints, weak formulations have a long tradition commonly providing a much higher degree of flexibility in the geometric modeling process at the price of an increased complexity of the mathematical model and the associated solution process.

With this contribution we give an overview about recent trends and developments for the enforcement of boundary conditions and coupling constraints in isogeometric methods. We will highlight the challenges, the potential and the limitations of strong and weak methods to enforce coupling and boundary condition constraints. We will further demonstrate a Nitsche-based extension of the equations governing the elasticity problem that turns out to be well-suited for both, weakly enforced essential boundary conditions and weakly enforced coupling constraints. With a fictitious domain extension based on the finite cell method the proposed concept is even capable to couple trimmed, overlapping and non-conforming patches along interfaces of arbitrary geometry such as curved and intersecting shell-like structures. We study the accuracy, reliability and convergence properties with several benchmark studies and demonstrate the high potential of the method for large-scale industry-relevant problems consisting of multiple patches.

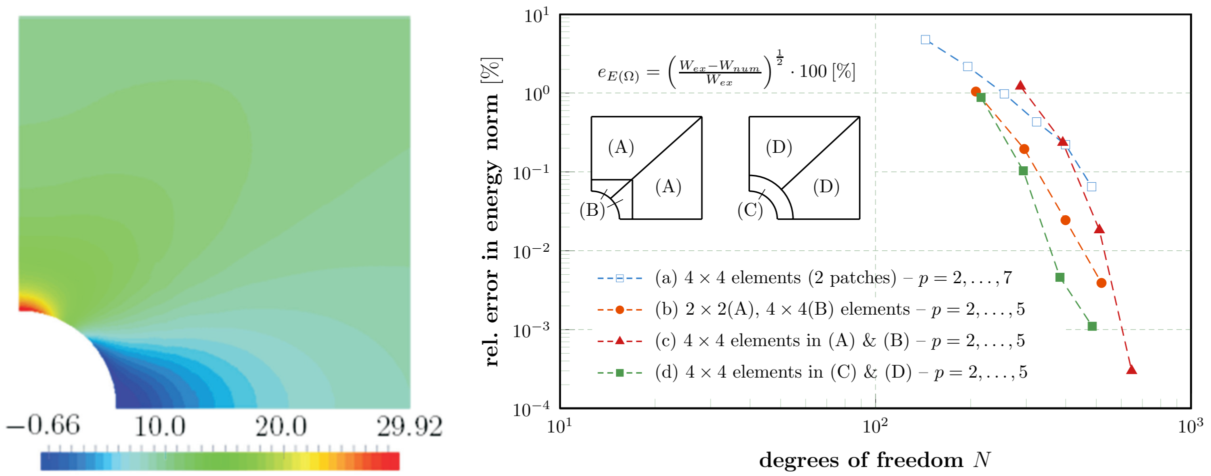

Figure 1: Example of an infinite plate with a circular hole under in-plane far field traction applying symmetry boundary conditions along the lower and left edge and exact traction values at the remaining edges: normal stress distribution σ_{xx} (left), convergence behavior under uniform p-refinement for various patch models (right)

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