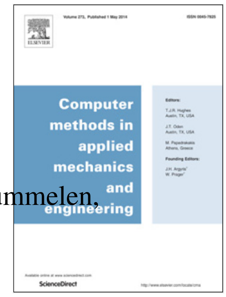

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Skeleton-stabilized IsoGeometric Analysis: High-regularity Interior-Penalty methods for incompressible viscous flow problems

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Abstract

A Skeleton-stabilized IsoGeometric Analysis (SIGA) technique is proposed for incompressible viscous flow problems with moderate Reynolds number. The proposed method allows utilizing identical finite dimensional spaces (with arbitrary B-splines/NURBS order and regularity) for the approximation of the pressure and velocity components. The key idea is to stabilize the jumps of high-order derivatives of variables over the skeleton of the mesh. For B-splines/NURBS basis functions of degree k with C^{α}-regularity ($0 \leq \alpha < k$), only the derivative of order $\alpha + 1$ has to be controlled. This stabilization technique thus can be viewed as a high-regularity generalization of the (Continuous) Interior-Penalty Finite Element Method. Numerical experiments are performed for the Stokes and Navier-Stokes equations in two and three dimensions. Oscillation-free solutions and optimal convergence rates are obtained. In terms of the sparsity pattern of the algebraic system, we demonstrate that the block matrix associated with the stabilization term has a considerably smaller bandwidth when using B-splines than when using Lagrange basis functions, even in the case of C^0-continuity. This important property makes the proposed isogeometric framework practical from a computational effort point of view.

Keywords: Isogeometric analysis, Skeleton-stabilized, High-regularity interior-penalty method, Stokes, Navier-Stokes, Stabilization method

1. Introduction

Isogeometric analysis (IGA) was introduced by Hughes *et al.* [1] as a novel analysis paradigm targeting better integration of Computer Aided Design (CAD) and Finite Element Analysis (FEA). The pivotal idea of IGA is that it directly inherits its basis functions from CAD modeling, where Non-uniform Rational B-splines (NURBS) are the industry standard. For analysis-suitable CAD models, geometrically exact analyses can be performed on the coarsest level of the CAD geometry. This contrasts with conventional FEA, which typically uses Lagrange polynomials as basis functions defined on a geometrically approximate mesh. An additional highly appraised property of IGA is that splines allow

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