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# Skew-symmetric Nitsche's formulation in isogeometric analysis: Dirichlet and symmetry conditions, patch coupling and frictionless contact

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**Abstract**

A simple skew-symmetric Nitsche's formulation is introduced into the framework of isogeometric analysis (IGA) to deal with various problems in small strain elasticity: essential boundary conditions, symmetry conditions for Kirchhoff plates, patch coupling in statics and in modal analysis as well as Signorini contact conditions. For linear boundary or interface conditions, the skew-symmetric formulation is parameter-free. For contact conditions, it remains stable and accurate for a wide range of the stabilization parameter. Several numerical tests are performed to illustrate its accuracy, stability and convergence performance. We investigate particularly the effects introduced by Nitsche's coupling, including the convergence performance and condition numbers in statics as well as the extra "outlier" frequencies and corresponding eigenmodes in structural dynamics. We present the Hertz test, the block test, and a 3D self-contact example showing that the skew-symmetric Nitsche's formulation is a suitable approach to simulate contact problems in IGA.

*Keywords:* Isogeometric, Nitsche, parameter-free, contact, patch coupling, boundary conditions.

## 1. Introduction

The key concept in isogeometric analysis (IGA) [56] consists in using non-uniform rational B-splines (NURBS) as basis functions to approximate both the geometry and the unknown physical fields. The mathematical foundations of IGA are developed in [12], and a recent overview is given in [70]. Contrary to classical Lagrange basis functions usually adopted in the finite element method (FEM), NURBS in IGA

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