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An isogeometric indirect boundary element method for solving acoustic problems in open-boundary domains

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Abstract

This work introduces an indirect Boundary Element Method (BEM) within a NURBS-based isogeometric framework for solving three-dimensional acoustic problems in the frequency domain. Developments of isogeometric boundary elements so far have focused on the direct BEM. Yet, a multitude of common problems in acoustics involves open-boundary surfaces, which require a more involved, indirect, boundary element formulation. The current work presents an indirect variational BEM which makes use of NURBS shape functions. Additionally, a novel technique for coupling (strongly) non-conforming patches is introduced to allow the analysis of more complex geometries. The proposed isogeometric indirect boundary element method is verified against analytical solutions and benchmarked against the conventional polynomial-based indirect BEM. Also two open-boundary problems are studied, including analyses over wider frequency ranges, and one industrial-type, complex geometry containing multiple non-conforming patches. The proposed method is found to be not only significantly more efficient than its polynomial-based counterpart, but also very robust against strong non-conformities in the NURBS descriptions.

Keywords: time-harmonic acoustics, isogeometric analysis, boundary element method, NURBS, non-conforming meshes

1. Introduction

The vibro-acoustic performance of a product has become a key design factor in recent years, in particular in the machine industry. This is partially due to ever tightening regulations on noise emission and exposure to vibration levels, but also commercial considerations play an important role: the acoustic character of an object has become a distinguishing feature that is often linked to a quality assessment of the entire product. In addition, acoustic engineers have increasingly less freedom in their designs due to the current trend toward lighter and more energy-efficient products. The lower weight of such designs inevitably leads to deteriorated noise and vibration properties. These strict legislative and commercial requirements together with the availability of ever stronger

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