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EXTENDED ISOGEOMETRIC BOUNDARY ELEMENT METHOD USING THE NUMERICAL STEEPEST DECENT

Jon Vegard Venås[1] and Trond Kvamsdal[1]

[1] Department of Mathematical Sciences
Norwegian University of Science and Technology (NTNU), 7491 Trondheim, Norway
jon.venas@ntnu.no, trond.kvamsdal@ntnu.no

ABSTRACT

Isogeometric analysis [1] (IGA) of acoustic scattering on unbounded domains has, as in many other fields, shown promising results. Methods that introduce an artificial boundary (infinite element method, PML-method, etc.) to handle the unbounded domain introduce the problem of surface-to-volume parametrization between the scatterer and the artificial boundary reducing the quality of the bridge between design and analysis provided by IGA. As the boundary element method (BEM) avoids this problem in only requiring a parameterization of the scatterer, it represents the ideal bridge between design and analysis using IGA. As for the classical boundary element method, the resulting basis functions in IGABEM is not suited for highly oscillatory problems. An attempt to solve this problem is by enriching the basis functions with oscillatory functions as in [3].
Building upon the work by Peak et al. [3] and Simpson et al. [4], we try to solve the problem of integrating highly oscillatory functions using the numerical steepest decent method [2]. We here restrict ourselves to 3D rigid scattering in homogeneous unbounded domains governed by the Helmholtz equation. The implementation is tested on the sphere problem before extending to a much more complicated submarine benchmark problem.

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ISOGEOMETRIC ENERGY BOUNDARY ELEMENT METHOD FOR HIGH FREQUENCY ACOUSTICS

Sören Keuchel[1], Matthias Ram[2], Olgierd Zaleski[1], and Otto von Estorff[2]

[1] Novicos GmbH, Kasernenstraße 12, 20173 Hamburg, Germany
keuchel@novicos.de / zaleski@novicos.de

[2] Institute of Modelling and Computation, Hamburg University of Technology, Denickestraße 17, 21073 Hamburg, Germany
matthias.ram@tuhh.de / estorff@tuhh.de

ABSTRACT

In an Isogeometric Analysis (IGA) exact CAD geometries are directly used as a basis for numerical simulations. This procedure can be incorporated to the Energy Boundary Element Method (EBEM) in order to achieve a fast and reliable engineering tool for analyzing acoustics. The energy methods are based on high frequency assumptions to approximate the solution. Instead of using the sound pressure and the acoustic flux as the variables, the energy density is the unknown quantity, which behaves much smoother than the highly oscillating acoustic values. Due to this, an almost frequency independent discretization can be applied. Therefore, the NURBS are a highly recommended simulation basis to connect the fast acoustic simulation with an easy incorporation of the changes in the CAD software. The design engineer develops different variants of the component and is able to judge very fast about the acoustical properties in a wide frequency range. The application area is rather unrestricted, i.e. the radiation of small actuators, the analysis of a car cabin, and even the analysis of concert halls. In this contribution the governing equations for the EBEM as well as the combination into an IGA is outlined. Numerical examples show the reliable procedure and the effectiveness of the presented formulation.

COUPLING BOUNDARY ELEMENT AND FINITE ELEMENT ANALYSIS FOR THE EFFICIENT SIMULATION OF FLUID-STRUCTURE INTERACTION PROBLEMS

Maximilian Harmel, Michał P. Rajski, and Roger A. Sauer

Aachen Institute for Advanced Study in Computational Engineering Science (AICES),
RWTH Aachen University, Templergraben 55, 52056 Aachen, Germany
harmel@aices.rwth-aachen.de
michal.rajski@rwth-aachen.de
sauer@aices.rwth-aachen.de

ABSTRACT

An isogeometric boundary element (BE) collocation formulation for Stokes flow is presented in this work. The key idea of the boundary element method (BEM) is to express the solution of a partial differential equation (PDE) in terms of boundary distributions of their fundamental solution. Thus, a three-dimensional Stokes problem can be solved efficiently on its two-dimensional boundary. Since the fundamental solutions contain singularities at the boundary, the use of special quadrature techniques is beneficial. A nonsingular BEM formulation and different quadrature rules are investigated and compared to standard Gaussian quadrature. Efficiency and functionality of the BE formulation are illustrated with numerical experiments considering Stokes flow within and outside of closed rigid boundaries [1].

The BEM is further used to model flow within and outside of deformable boundaries. The motion of the boundary is described with a nonlinear finite element (FE) surface model for membranes [2] and shells [3]. A monolithic formulation is presented to couple boundary element (Stokes flow) and finite element (membranes and shells) method. A common curvilinear surface parameterization is used for BE and FE analysis to admit general surface shapes and deformations. Geometry and PDEs are spatially discretized using C1-continuous NURBS basis function for interpolation, while the temporaly discretization is realized with the generalized-α scheme.

The behavior of the coupled system is illustrated by several numerical examples that investigate fluid-structure interaction problems considering Stokes flow within droplets and liquid-filled balloons (including mechanical contact) and outside of bubbles.

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