An Isogeometric Variational Method for Analysis of Structural-acoustic Coupling Systems with Arbitrary Bounded Domains

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Abstract

For vibro-acoustic problems, the variational method based on Lagrange's functional and orthogonal polynomial expansion exhibits excellent accuracy and satisfactory efficiency, yet only confines to computational domains with simple and regular shapes. Domain decomposition technique, wave-based methods, or isoparametric transformation methods have been used to address this issue, but inevitably result in cumbersome mathematical manipulations and unwanted coupling errors. Aiming at improving the geometrical adaptivity of the variational method, this paper incorporates the non-uniform rational B-spline (NURBS)-based isogeometric approach into the formulation of weak-form elasto-acoustic equations that governs the coupled problem. Specifically, the arbitrarily bounded physical fields are precisely represented in the form of NURBS patch with associated control points and weight factors, and then mapped into a unit spectral domain by the isogeometric procedure, on which the Chebyshev orthogonal polynomials of the first kind are steadily built and further employed as wholly admissible functions for the Lagrange's function of the coupled problem. Dynamic properties of the acoustic field can be calculated based on discretized governing equations of the system. The merit of the proposed approach is that it simultaneously maintains the higher accuracy of variational methods and the exact representation of NURBS geometries, which is validated by several numerical examples against benchmark solutions, as well as by comparisons with the classical and isogeometric finite element methods.

Keywords: Structural-acoustic coupling, isogeometric approach, variational method, NURBS.