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Editorial

Introduction to the Special Issue on Recent Developments of Isogeometric Analysis and Its Applications in Structural Optimization

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Isogeometric analysis (IGA), which aims at integrating CAD and CAE models, is one of the most active research topics in both computational mechanics and computer-aided geometric design. The rapidly growing interests in IGA has led to profound developments of relevant theories and applications, one of which being structural optimization. With the rapid growth of researches in IGA, this special issue contributes to highlight recent developments, challenges and opportunities of IGA and IGA-based structural design optimization, with focuses on theory development, numerical implementations and potential applications.

This special issue is organized by six guest editors who have made important contributions in the field of IGA and IGA-based design and structural optimization. There are 13 papers accepted after a critical peer review process. The topics include analysis-suitable parameterization methods, isogeometric shape and topology optimization, multiscale isogeometric structural optimization, and others.

We summarize the accepted papers in this special issue as follows:

In the paper entitled "Data-driven structural design for petal-shaped auxetics using isogeometric analysis" by Wang et al. [1], the authors propose a back-propagation neural network (BPNN) based design framework for petal-shaped auxetics using IGA. The BPNN-based fitting method is used to build the nonlinear relation between the input geometry variables and the effective material properties, which enable an easy analytical sensitivity analysis, in contrast to the generally complex procedures of typical shape and size sensitivity approaches.

Wu et al. [2] present an approach to reuse the basis function evaluations in the numerical integration of IGA in the paper entitled "Reusing the evaluations of basis functions in the integration for isogeometric analysis". The authors classify the bases on the original level and then reuse them on the refined level, which can reduce the time for basis calculations at integration nodes. By using the sum factorization method and the mean value theorem for the integrals, an integration method with high efficiency is proposed.

In the paper "Multiresolution isogeometric topology optimization using moving morphable voids" studied by Du et al. [3], a general and new explicit isogeometric topology optimization approach with moving morphable voids (MMV) is proposed. In this approach, a novel multiresolution scheme with two

distinct discretization levels is developed to obtain high-resolution designs with a relatively low computational cost.

Yu et al. [4] studied a multiscale isogeometric topology optimization (ITO) method where the configuration and layout of microstructures are optimized simultaneously. A shape deformation method is used to obtain a series of graded microstructures, and the effective mechanical properties are estimated by the homogenization method. IGA is integrated into the level set framework that generates the microstructural skeleton. The numerical examples demonstrate that the proposed method is effective in improving the structural performance and manufacturability.

In the IGA and IGA-based topology optimization using T-splines, Zhao et al. contribute two papers, e.g., "T-splines for isogeometric analysis of two-dimensional nonlinear problems" by Guo et al. [5] and "T-splines based isogeometric topology optimization with arbitrarily shaped design domains" by Zhao et al. [6]. The former focuses on the T-spline based IGA of 2D nonlinear problems, and the latter proposes a new topology optimization with arbitrarily shaped design domains using T-splines based IGA.

In the paper titled "Parametric structural optimization of 2D complex shape based on isogeometric analysis" presented by Chen et al. [7], a structural optimization method of parametric complex shapes is proposed by using IGA, where a feature frame model is built by the given feature curves and constraints. In this method, the parametric modeling and structural optimization can be united together without model conversion.

Mei et al. [8] introduce a topology optimization method for variable stiffness composite panels with varying fiber orientation and curvilinear fiber path in their paper "IGA based bi-layer fiber angle optimization method for variable stiffness composites", where the IGA is used for the numerical computation. The bi-layer fiber paths are generated using streamline method and updated by divided pieces reselection method after the topology optimization process.

Xu et al. [9] propose an approximating method to construct high precision single-patch representation of B-spline surface from a multi-patch representation for IGA in the paper "A high-accuracy single patch representation of multi-patch geometries with applications to isogeometric analysis". Xia et al. [10] investigate the geometric fitting method for curved beam structure from points to obtain high-quality parametric isogeometric models in the paper of "Analysis-aware modelling of spacial curve for isogeometric analysis of Timoshenko beam".

On the topic IGA using boundary integration methods, there are two articles, e.g., "Resolving domain integral issues in isogeometric boundary element methods via radial integration: a study of thermoelastic analysis" by Wang et al. [11] and "Interpolating isogeometric boundary node method and isogeometric boundary element method based on parameter space" by Yang et al. [12]. The first one investigates the isogeometric boundary element method for thermoelastic problems, where the NURBS used to construct geometric models is employed to discretize the boundary integral formulation. The second proposes a method to interpolate isogeometric boundary nodes and utilizes it with isogeometric boundary element method to solve 2D elasticity problems, with the accuracy of the methods analyzed using numerical examples.

Yu et al. [13] propose a patch-removing-based IGA method to conduct the analysis for the holed structures with only one parametric domain in their paper "Isogeometric analysis and shape optimization of holed structures via the patch removing technique". In this method, the holed structures are obtained by removing sub-patches from an intact base patch without generating trimmed elements.

In summary, we hope the studies collected in this special issue can inspire further researchers to contribute to the development of isogeometric analysis and design optimization.

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Conflicts of Interest: The authors declare that they have no conflicts of interest to report regarding the present study.

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