Isogeometric analysis based gradient shape optimization. Algorithmic differentiation of isogeometric PDE solvers.

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ABSTRACT

Over the last decade, Isogeometric Analysis (IGA) [1] has become an established framework that receives wide acceptance both from academia and industry. After several years of bringing the methodology itself to maturity, current research focuses on the applicability of IGA in complex industrial process like, for instance, deterministic shape optimization. Both IGA and shape optimization techniques require a direct link to the underlying geometry model, which often stems from a Computer-aided design (CAD) software and provides a parametric description of the shape in terms of B-Spline or NURBS basis functions. The shape can be modified by varying the location of the control points, thereby leaving the set of basis functions, and hence, the topological structure unchanged, which significantly simplifies discretization of the problem at each optimization step.

Gradient shape optimization is a very promising approach in combination with IGA [2]. Despite its many advantages, gradient optimization requires an evaluation of the gradient at every optimization step. Standard methods like approximating the gradient by finite differences lead to enormous computational effort in case of complex geometries. Algorithmic Differentiation (AD) is one of the few methods that avoid excessive computational cost in the gradient evaluation [3, 4].

In this talk, we discuss the theoretical background and present our implementation of gradient shape optimization loop based on the open-source AD package CoDiPack (`https://github.com/scicompkl/codipack`) which we integrated into the IGA library G+Smo (`https://www.gs.jku.at/gismo`).

REFERENCES

[1] T.J.R. Hughes, J.A. Cottrell, and Y. Bazilevs, "Isogeometric analysis: CAD, finite elements, NURBS, exact geometry and mesh refinement", *Comput. Methods Appl. Mech. Engrg.*, Vol. **194**, pp. 4135-4195 (2005).

[2] D. Fußeder, B. Simeon, V. V. Vuong, "A Framework for Shape Optimization in the context of Isogeometric Analysis", *Journal of Comput. Methods Appl. Mech. Engrg.*, Vol. **286**, pp. 313-331 (2014).

[3] N.R. Gauger, "Efficient Deterministic Approaches for Aerodynamic Shape Optimization", *Optimization and Computational Fluid Dynamics*, pp. 11-145, Springer (2005).

[4] A. Griewank, "On Automatic Differentiation", *Mathematical Programming: Recent Developments and Applications*, pp. 83-108, Kluwer Acadamic Publishers (1989).