Discrete differential forms based on T-splines

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Abstract

Isogeometric Analysis (IGA) is a method introduced for the discretization of partial differential equations (PDE), that was introduced in [1] with the aim of improving the interoperability between computer aided design software (CAD) and PDE solvers. In the first papers, IGA was based on B-splines and non-uniform rational B-splines (NURBS), a set of functions that are spreadly used in CAD. The method has two main features: it allows to maintain a NURBS description of the geometry, and, compared to FEM, the solution is more regular, since NURBS of degree p can have up to $p-1$ continuous derivatives.

In [2] we extended the idea of IGA to discrete differential forms. The method is based on the construction of an exact sequence of B-spline spaces with mixed degree, and it can be understood as a generalization of edge and face finite elements with higher regularity. In that paper we also defined a family of L^2 stable projectors that, along with the continuous and discrete spaces, form a commuting De Rham diagram.

The main drawback of B-splines and NURBS is their tensor product structure, which does not permit local refinement. To overcome this problem, it was proposed in [3] a discretization based on T-splines. T-splines are a family of functions defined on meshes with hanging nodes, allowing for local refinement, and with the same regularity properties of NURBS and B-splines. Under mild assumptions on the distance between hanging nodes, it can be proved that T-spline spaces have good approximation properties.

Recently, we have extended the definition of isogeometric differential forms to T-splines, defining an exact sequence of T-spline spaces that generalizes the result for tensor product B-splines [4]. In this work I will present the latest results in the study of this T-splines compatible discretization, along with a brief review on the previous B-splines results.

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. and Engrg.*, 194(39-41):4135-4195, 2005.

[2] A. Buffa, J. Rivas, G. Sangalli, and R. Vázquez. Isogeometric discrete differential forms in three dimensions. SIAM *J. on Numer. Anal.*, 49(2):818-844, 2011.

[3] Y. Bazilevs, V. M. Calo, J. A. Cottrell, J.A. Evans, T. J. R. Hughes, S. Lipton, M. A. Scott, and T. W. Sederberg. Isogeometric analysis using T-splines. *Comput. Methods Appl. Mech. Engrg.*, 199(5-8):229-263, 2010.

[4] A. Buffa, G. Sangalli, and R. Vázquez. Isogeometric methods for computational electromagnetics: B-splines and T-splines discretizations. *Submitted.*

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