Extraction and Optimization of Watertight Spline Layouts from Trimmed Geometries using Dual Loops

Kendrick M. Shepherd[1]*, René R. Hiemstra[2], Lulin Quan[3], and Thomas J. R. Hughes[4]

[1, 2, 3, 4]Oden Institute for Computational Engineering and Sciences
The University of Texas at Austin
201 E. 24th Street, POB 4.102
1 University Station (C0200)
Austin, Texas 78712-1229, USA
e-mail: [1]kendrick@ices.utexas.edu, [2]rene@ices.utexas.edu,
[3]quanlulin@gmail.com, [4]hughes@ices.utexas.edu

ABSTRACT

In this work we discuss a streamlined, semiautomatic methodology to convert trimmed CAD geometries into geometries suitable for both engineering design and analysis. Built in the framework of existing CAD functionality, this process yields a globally semi-structured, geometry-aware spline layout without T-junctions. Through this conversion, the challenges associated with analysis of trimmed objects (which is the current bottleneck in the engineering design/analysis process) can be avoided.

While isogeometric analysis aims to streamline the design through analysis process, analysis on many objects of engineering interest is impossible due to “dirty” trimmed geometries. An obvious route to fixing this issue is to rebuild the geometry into its intended form. While local restructuring schemes exist, it may be desirable to extract a global restructuring. Such a technique should mitigate the number of patches introduced, introduce geometrically meaningful (and relatively few) extraordinary points (EPs), and fit the geometry exactly where there is no trim-induced ambiguity. Furthermore, the operations should be fast and semi-automatic to facilitate design-aware decisions. To this end, we employ tools from computational geometry and topology to extract quad layouts on a geometry-aware underlying triangular mesh of the B-Rep [1]. In this framework, patch layouts on the mesh may be computed which minimize an appropriate energy [2]. These layouts, computed automatically, can immediately be used as a skeleton for rebuilding the intended B-Rep. Alternatively, the dual layout to the intended patch layout (see [3]) can be used to introduce user-provided constraints to improve qualities such as symmetry and EP connectivity. Finally, the original B-Rep is rebuilt into a watertight representation by projecting the computed layout on the underlying mesh to the trimmed geometry and appropriately extracting control points, weights, and knots from the trimmed surface. The toolset that facilitates this spline-rebuilding process lives within the functionality of existing CAD software.

These tools are a step towards the realization of IGA’s ultimate goal: a streamlined design, analysis, and manufacturing process.

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