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Towards an Automatic Isogeometric Analysis Suitable Trivariate Models Generation - Application to Geometric Parametric Analysis

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Abstract

This paper presents an effective method to automatically construct trivariate tensor-product spline models of complicated geometry and arbitrary topology. Our method takes as input a solid model defined by its triangulated boundary surface. Using cuboid decomposition, an initial polycube approximating the input boundary mesh is built. This polycube serves as the parametric domain of the tensor-product spline representation required for isogeometric analysis. The polycube's nodes and arcs decompose the input model's boundary into quadrilateral patches, and these patches form hexahedral domains. Using aligned global parameterization, the nodes are re-positioned and the arcs are re-routed across the surface in a way to achieve low overall patch distortion, and alignment to principal curvature directions and sharp features. The optimization process is based on one of the main contributions of this paper: a novel way to design cross fields with topological (i.e., imposed singularities) and geometrical (i.e., imposed directions) constraints by solving only sparse linear systems. Based on the optimized polycube and parameterization, compatible B-spline boundary surfaces are reconstructed. Finally, the interior volumetric parameterization is computed using Coon's interpolation. In the context of parametric studies based on geometrical parameters, this method can be used to compute the morphing required for reduced order modeling. For different parametric instances with the same topology but different geometries, this method allows to have the same representation: i.e., meshes (or parameterizations) with the same topology. The efficiency and the robustness of the proposed approach are illustrated by several examples.

Keywords: Isogeometric Analysis, Reduced Order Modeling, Trivariate NURBS, Cuboid Decomposition, Cross Field Design, Global Parameterization