Quadrilateral Parameterization and Layout Simplification for Open Surfaces Using Homotopy Theory

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Abstract

Quadrilateral mesh generation plays a critical role in generating shell models for structural analysis, for reconstructing computer-aided design spline models, and for mapping and sweeping operations for volumetric meshes. Recent techniques for quadrilateral mesh generation focus on defining a layout-inducing parameterization and then prescribing appropriate constraints, often through integer-based optimization, to both ensure validity of the parameterization and to yield meshes with high quality connectivity between singular points. In this work, we present an alternative approach to prescribe connectivity constraints for parameterization-based quadrilateral mesh generation based on homotopy theory of branched covering spaces defining quadrilateral layouts [1]. Important theoretical motivation is first discussed, after which the theory is leveraged for automated layout improvement for a variety of industrial shell structures.

References

[1] K. M. Shepherd, X. D. Gu, R. R. Hiemstra, and T. J. R. Hughes, *Quadrilateral layout generation and optimization using equivalence classes of integral curves: Theory and application to surfaces with boundaries*, J. Mech., 38 (2022), pp. 128–155.

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