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A Mesh Regularization Scheme for Updating Internal Control Points in Isogeometric Shape Optimization

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Abstract

This paper presents a variational method for updating internal control points in isogeometric shape optimization. The significant properties of domain parameterization such as bijective mapping between parametric and physical domains, uniformity and orthogonality of mesh are enforced simultaneously. The bijective mapping is achieved through minimizing a Dirichlet energy functional. To prevent the divergent behavior of the minimizing process due to the severe distortion of the initial mesh, a constraint is introduced to enforce the positive Jacobian of mapping from parametric to physical domains. Despite the employing of the constraints that might increase computational costs, the proposed method is more efficient due to the convexity of Dirichlet energy functional, compared with the other unconstrained methods. Also, it turns out that the proposed method is more effective to achieve the bijective mapping, especially near a concave boundary. The uniform parameterization of the domain is achieved through minimizing the Dirichlet energy functional and the orthogonality of mesh by minimizing a dimensionless functional. The sensitivity of the employed functional and constraint is analytically derived with respect to the position of internal control points. The developed scheme of mesh regularization is employed in several numerical examples of the isogeometric shape optimization, and is shown to be effective to maintain the high quality of domain parameterization during the shape optimization process.

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