Diverse Benchmark Configuration-Driven Mesh Deformation Method Postprint

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Abstract

Due to advantages such as eliminating the need for remeshing and operational simplicity, mesh deformation methods are widely applied in shape optimization. However, for shape optimization design in compact design spaces, traditional mesh deformation methods driven by a single baseline configuration are prone to mesh element distortion, boundary mesh interference, and other issues, leading to mesh deformation failure and interruption of the shape optimization process. To address these challenges, a mesh deformation method driven by diverse baseline configurations is proposed. First, multiple baseline configurations are constructed in the design space to obtain their corresponding mesh models. Then, boundary nodes of the mesh models are selected as control points, and each baseline configuration is independently deformed toward the same target shape using radial basis function interpolation. Furthermore, mesh element quality metrics are established to evaluate the deformed mesh models of each baseline configuration, and the model with optimal mesh quality after deformation is selected for analysis and subsequent shape optimization design, with control point displacement as input and structural stress from analysis as output. Finally, method verification is performed through a two-dimensional axisymmetric turbine disk example. The results demonstrate that, compared with traditional mesh deformation methods, the proposed method reduces the mesh deformation failure rate by 59% and increases the weight reduction by 46%, thereby validating that the new method effectively reduces mesh deformation failure rates and ensures successful shape optimization implementation for structures in compact design spaces.

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