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Optimal design by adaptive mesh refinement on shape optimization of flow fields considering proper orthogonal decomposition. (English) Zbl 1452.65245

Summary: This paper presents optimal design using Adaptive Mesh Refinement (AMR) with shape optimization method. The method suppresses time periodic flows driven only by the non-stationary boundary condition at a sufficiently low Reynolds number using Snapshot Proper Orthogonal Decomposition (Snapshot POD). For shape optimization, the eigenvalue in Snapshot POD is defined as a cost function. The main problems are non-stationary Navier-Stokes problems and eigenvalue problems of POD. An objective functional is described using Lagrange multipliers and finite element method. Two-dimensional cavity flow with a disk-shaped isolated body is adopted. The non-stationary boundary condition is defined on the top boundary and non-slip boundary condition respectively for the side and bottom boundaries and for the disk boundary. For numerical demonstration, the disk boundary is used as the design boundary. Using $H^1$ gradient method for domain deformation, all triangles over a mesh are deformed as the cost function decreases. To avoid decreasing the numerical accuracy based on squeezing triangles, AMR is applied throughout the shape optimization process to maintain numerical accuracy equal to that of a mesh in the initial domain. The combination of eigenvalues that can best suppress the time periodic flow is investigated.

MSC:
65M60 Finite element, Rayleigh-Ritz and Galerkin methods for initial value and initial-boundary value problems involving PDEs
65N30 Finite element, Rayleigh-Ritz and Galerkin methods for boundary value problems involving PDEs
65N50 Mesh generation, refinement, and adaptive methods for boundary value problems involving PDEs
65M06 Finite difference methods for initial value and initial-boundary value problems involving PDEs
68M99 Computer system organization
65K10 Numerical optimization and variational techniques
65H10 Numerical computation of solutions to systems of equations
65F15 Numerical computation of eigenvalues and eigenvectors of matrices
65F50 Computational methods for sparse matrices
49Q10 Optimization of shapes other than minimal surfaces
49Q12 Sensitivity analysis for optimization problems on manifolds
76D05 Navier-Stokes equations for incompressible viscous fluids
35Q30 Navier-Stokes equations

Keywords:
adaptive mesh refinement; adjoint method; cavity flow; proper orthogonal decomposition; shape optimization problem

Software:
FreeFem++; UMFPACK

Full Text: DOI

References:


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