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A Hybrid Mesh/Meshless CFD Solver Coupled with Genetic Algorithms for Solving Inverse Design Problems in Aerodynamics

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ABSTRACT

A hybrid computational fluid dynamics (CFD) solution method coupled with genetic algorithms (GAs) is presented for solving inverse design problems in this paper. The hybrid method combines both mesh and meshless techniques, in which the flow field is basically discretized by Cartesian grids while a local meshless treatment is embedded in the close vicinity of bodies. Due to Cartesian mesh's regularity and orthogonality, this new approach not only provides an efficient mesh generation with a simple implementation of numerical schemes, but also eliminates issues associated with mesh skewness and distortion. Moreover, the local meshless technique only requires a few points distributed in the vicinity of the aerodynamic geometries making the proposed method flexible and well suited to arbitrary configurations.

Feeded by the above mesh/meshless hybridized CFD solver, a GAs is then used to solve shape and position inverse design problems. In order to investigate the efficiency of the inverse procedure coupled with the hybrid solver, an analytical potential flow over a cylinder in a rectangular channel is considered as an initial validation step. The comparison presented on figure 1 shows that the numerical solution agrees quite well with the exact solution, and demonstrates the validation of hybrid method. Several numerical experiments of inverse design problems of an ellipse considering different thickness and variable position are also presented to illustrate the potential of this methodology in terms of accuracy, efficiency and flexibility.

A straightforward extension of this coupled hybrid algorithm/optimization approach to more complex flow modeling using the solution of the compressible Euler or Navier Stokes equations around aerodynamic multi-element shapes will be also discussed.

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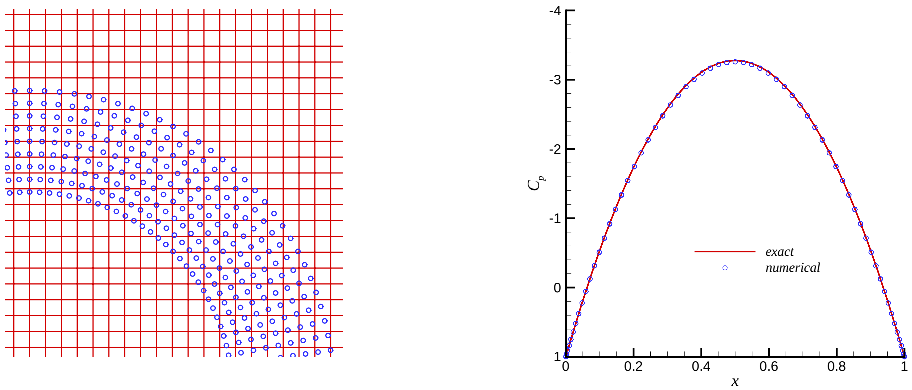
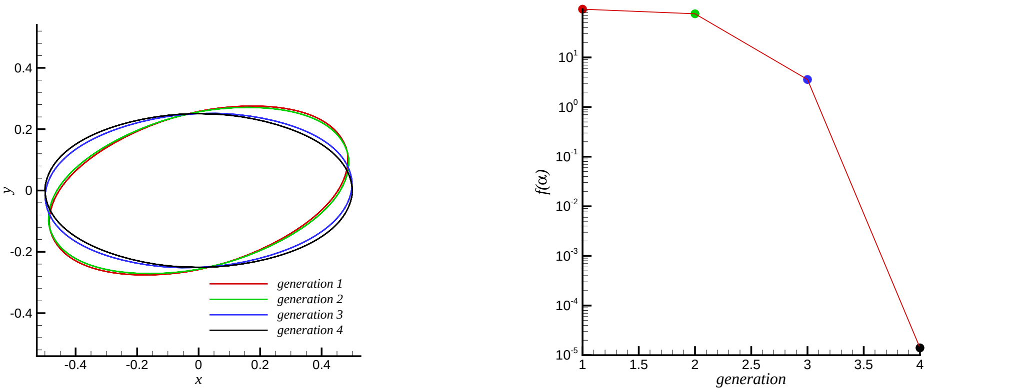


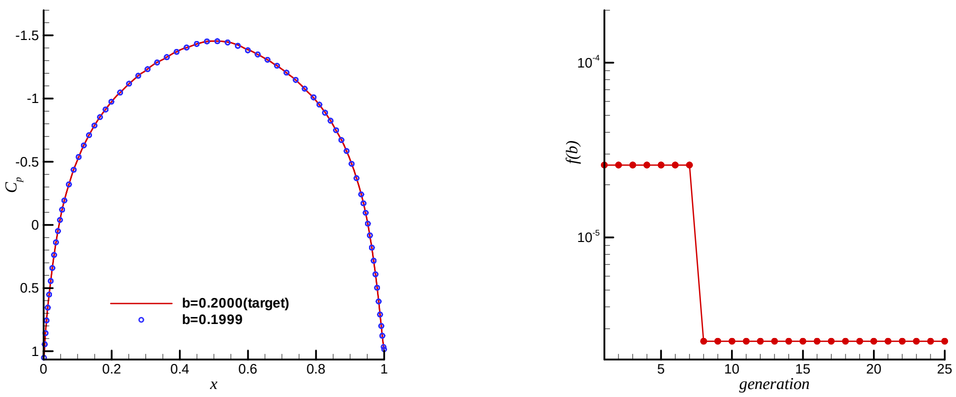
(a) Mesh and clouds near the cylinder (b) Pressure coefficients around the cylinder

Figure 1: Hybrid CFD solution (Ideal Incompressible flow over a cylinder)



(a) Position of the ellipse (b) Convergence history of target function

Figure 2: Inverse design problem of rotation angle for the ellipse (Ideal Incompressible flow)



(a) Pressure coefficients around the ellipse (b) Convergence history of target function

Figure 3: Inverse design problem of thickness for the ellipse (Compressible Euler flow)