Surrogate-Based Aerodynamic Optimization via Gradient-Enhanced Kriging and Hierarchical Kriging

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Abstract

During the past decade, surrogate-based optimization (SBO) received increasing interest for aerospace engineering design problems (1) (2), such as aerodynamic design (3). It refers to a new type of numerical optimization methods which utilities so-called surrogate models, such as kriging, polynomial response surface, radial-basis functions, support vector regression, etc. to find the global or local optimum. The benefit of using SBO is that the efficiency of a global optimization can be dramatically improved, when high-fidelity, thus expensive numerical simulation method is employed.

Here we are mainly concerned with applying SBO for aerodynamic shape optimization. Traditionally, the expensive computational fluid dynamics (CFD) solver of single fidelity (such as Reynolds-averaged Navier-Stokes flow solver) is coupled with a surrogate-based optimizer to get the optimum aerodynamic shape. In this seminar, I will present our recent development of using the auxiliary, cheaper information, such as the gradient information obtained by adjoint method and the information obtained from the lower-fidelity CFD, to improve the quality and efficiency of the traditional surrogate-based optimization. The key idea is to use so-called gradient-enhanced kriging (4) and hierarchical kriging (5), in which gradient information or lower-fidelity functional value (6) is incorporated to build a more accurate kriging surrogate model. Test cases on analytical functions, inverse design and drag minimization of transonic airfoils will be presented. The investigation shows that the new methods feature faster convergence and can give better optimal results, for both local and global optimization problems.

References

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