A metamodel updating strategy for multi-objective optimization with expensive simulation models

***F.L. Gao[1,2], †Y.C. Bai[1,2], and C. Lin[1,2]**

[1]National Engineering Laboratory for Electric Vehicles, School of Mechanical Engineering, Beijing Institute of Technology, China
[2]Collaborative Innovation Center of Electric Vehicles in Beijing, Beijing Institute of Technology, China

*Presenting author: ga.go@163.com
†Corresponding author: baiyc@bit.edu.cn

Abstract

To solve structure design problems with expensive simulation models, metamodeling technique has been widely incorporated into multi-objective optimization (MOO) to accelerate the design efficiency. Regarding MOO using metamodels, metamodel accuracy and optimization efficiency are the main concerned issues. To accelerate the optimization process as well as guarantee the metamodel accuracy, a metamodel updating strategy is proposed by using intelligent sampling (IS) approach and adaptive-weighted sum (AWS) method. The initial metamodel with respect to each objective and constraint referred is constructed by combining Radial Basis Function (RBF) and Latin Hypercube Sampling (LHS). The gradient-based AWS method is then employed to solve the approximate MOO problem based on the built metamodels to obtain the Pareto of Frontier (PoF) efficiently. The end points and the maximal-minimal-distance nearest point are identified, and the corresponding design parameters are selected as the concerned samples to be introduced into the sampling pools, which could gradually improve the accuracy of the constructed metamodel. A further point filer strategy is also developed to avoid the overlap of excessive samples, and whereby overcome numerical difficulties. This metamodel updating is performed until the difference between PoFs derived from two iterations satisfies the pre-determined threshold. A bunch of numerical examples are investigated to demonstrate the effectiveness of the proposed method in addressing MOO problems with convex, concave or simple discontinuous PoF. Specifically, it is noted that optimum schemes on the middle part of the final PoF obtained are preferred if the number of design variables is more than 3. Finally, the proposed method is applied for multi-objective design optimization of an electric bus body frame.

Keywords: Multi-objective optimization; Intelligent sampling technique; Adaptive weighted-sum method; Radial basis function

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