Structural Design Employing a Sequential Hybrid Approximate Optimization

Donghui Wang[1], Zeping Wu[1], Wenjie Wang[1], Kun Zhao[2,3] and Weihua Zhang[1]

1. National University of Defense Technology, No. 109 Deya Road Kaifu District Changsha Hunan China, 410073, Email: wangdonghui1984@sina.cn
2. State Key Laboratory of Aerodynamics, China Aerodynamics Research and Development Centre, Mianyang, Sichuan, 621000, China
3. Department of Mechanical and Manufacturing Engineering, Trinity College Dublin, University of Dublin, Dublin, Ireland

Key Words: *Sequential hybrid approximation optimization; Hybrid approximate model; adaptive sampling strategy; Structural design optimization.*

This paper presents a sequential hybrid approximate optimization (SHAO) algorithm suitable for structural design optimizations. With the existing trend of utilizing structural analysis processes as a seemingly ‘black box’ manner within the conventional SAO, this proposed SHAO breaks down the process and divide it into different stages: the time-consuming and hard-to-interpret FEA stage, as well as the well-assessed and easy-to-handle post-processing stage. The former is surrogated by field surrogate models and the latter is handled in a fundamental theoretical manner. This manipulation produces a hybrid model that enables the capture of more complex responses of the structural analysis process when compared to the ‘black-box’ models. By using the hybrid model, the constraints and objective are predicted more accurately when compared to the standard ‘black-box’ surrogate models. Therefore, the efficacy and efficiency of the optimization process can be improved substantially.

The proposed method was evaluated using two benchmark test cases: the 72-bar truss system and the 582-bar tower truss system. Compared with the result of the studies previously published, the SHAO algorithm yielded equivalent or much better objective values for the tested structural design optimization tasks. Additionally, the number of true function evaluations, required to find the same global optima, was significantly reduced by multiple orders of magnitude, which further highlights the applicability of the proposed SHAO algorithm towards engineering structural design optimization problems.

REFERENCES

[1] P W. Christensen, A Klarbring. An Introduction to Structural Optimization. Springer. 2008
[2] A. R. Yildiz. Comparison of evolutionary-based optimization algorithms for structural design optimization. Eng. Appl. Artif. Intell 2013; 26: 327-333.
[3] D. Wang，Z. Wu，Y. Fei，W. Zhang. Structural design employing a sequential approximation optimization approach. Comput Struct 2014; 134(4):75-87
[4] A. I. J. Forrester, A. J. Keane. Recent advances in surrogate-based optimization. Prog Aerosp Sci 2009; 45: 50-79.
[5] D. R. Jones. A taxonomy of global optimization methods based on response surfaces. J Glob Optim 2001; 21: 345-383.