Unified Ensemble of Surrogates (UES): a novel strategy of integrating global measures with local measures for engineering design and optimization

***†Jian Zhang[1], Jiajia Qiu[1], and Xinxin Yue[1]**

[1]Department of Mechanics and Engineering Science, Jiangsu University, China

*Presenting author: jianzhang@ujs.edu.cn
†Corresponding author: jianzhang@ujs.edu.cn

Abstract

For design and optimization of complex engineering systems, surrogate models (also known as metamodels) are widely used as the replacement of high-fidelity computer simulations to reduce the expensive computational cost. Commonly used surrogate models include polynomial response surface (PRS), radial basis functions (RBF) and Kriging (KRG). However, it is not apparent to know a priori which surrogate model is most desirable for an unknown problem.

Therefore, an ensemble of surrogate models has been developed recently by combing multiple surrogates through a weighted form to take advantage of the prediction ability of each individual surrogate and to eliminate the effort to select an appropriate individual. Existing ensemble modeling methods can be generally classified as global measures and local measures. The weight factors evaluated by global measures keep constant over the entire design space, while local measures determine the weight factors of individual surrogates at each sampling point respectively. Global measures are relatively straightforward, computationally inexpensive and generally accurate from the global perspective of view, but they may not reflect the diversity of each component surrogate. On the other hand, the ensemble model by using local measures is more flexible but less robust, because local error fluctuation may heavily deteriorate the model accuracy.

To this end, a unified ensemble of surrogates (UES) with integration of global and local measures is proposed in this paper. A coefficient of ensemble is devised to regulate the influences of global and local measures on the calculation of weight factors. The performance of the proposed UES is tested by a number of benchmark problems and several engineering examples of design and optimization. Four other ensemble models and three individual surrogate models are adopted to make comparisons with the UES. It is concluded that the proposed UES can provide more robust and accurate approximations with limited sample points for analysis of engineering design and optimization.

Keywords: Surrogate model; Metamodel; Ensemble; Global measure; Local measure

References

[1] Acar E, Rais-Rohani M (2009) Ensemble of metamodels with optimized weight factors. Structural and Multidisciplinary Optimization 37(3): 279–294.
[2] Goel T, Haftka RT, Wei S, Queipo NV (2007) Ensemble of surrogates. Structural and Multidisciplinary Optimization 33(3): 199–216.
[3] Acar E (2010) Various approaches for constructing an ensemble of metamodels using local measures. Structural and Multidisciplinary Optimization 42(6): 879–896.
[4] Chen LM, Qiu HB, Jiang C, Cai XW, Gao L (2018) Ensemble of surrogates with hybrid method using global and local measures for engineering design. Structural and Multidisciplinary Optimization 57(4): 1711–1729.