

REVIEW OF MULTI-FIDELITY SURROGATE MODELS

M. Giselle Fernandez-Godino^{*}, Chanyoung Park, Nam Ho Kim, Raphael T. Haftka

University of Florida
Gainesville, FL 32611

gisellefernandez@ufl.edu, cy.park@ufl.edu, nkim@ufl.edu, haftka@ufl.edu

ABSTRACT

Modern engineering design is often based on expensive high-fidelity (HF) simulations that allow exploration of a design space. Similarly, quantification of uncertainty in system response due to variability or uncertainty in input often requires use of HF simulations to explore the uncertain parameter space. When HF simulations are very costly, it is common to fit a number of simulations with an algebraic surrogate, and perform the optimization or uncertainty quantification based on the surrogate. However, in many cases, even performing the number of HF simulations needed to obtain an accurate algebraic surrogate is prohibitively costly. In such cases, one may resort to augmenting a small number of HF simulations with a large number of low-fidelity (LF) models that are inexpensive but less accurate.

The aim of this paper is to present an overview of the evolving use of MF techniques including a description of the multiple fidelities chosen by authors, the different ways that authors combine these fidelities and the savings provided. There is no universal agreement if the combination of simulations and experiments (treated as expensive high-fidelity results), often called calibration, is a MF approach. However, in this work it was treated as MF technique.

Sampling selection is the first step in MF surrogate construction. For this reason sampling strategies for selection of HF and LF samples available in the literature are presented first in this work. Then the most commonly used surrogate models in MF approaches are introduced, describing the different techniques for combining fidelities. The key distinction is between deterministic approaches and probabilistic approaches. Deterministic approaches include multiplicative correction, additive correction and space mapping. Probabilistic approaches include Bayesian and Co-kriging techniques. The paper also surveys the different relations between the, HF and LF models used by authors. These include changing the mathematical model, changing the numerical model, simplifying the physics or solving a simplified version of the problem. Because a key MF goal is to reduce computational expenses, a short summary of the savings accomplished using MF models is also included, presenting in some cases savings higher than 99%. Accuracy is also a pursued purpose and for that reason a discussion in this matter was carried out finding examples where validation using MF models instead of LF models is 4 times more accurate.

References

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- [7] *The paper will have more than 80 references. I included the first 8 references which fit in one page.*