Multiscale simulations via reduced-order modeling

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ABSTRACT

Hierarchical multiscale approaches are based on the general principle of divide-and-conquer: the original domain is divided into smaller regions; then, if possible, these regions are further subdivided into smaller pieces, and so on until arriving at the bottom level of the hierarchy, where it is necessary to resort to experimentally derived relationships is to be made. But the actual feature that distinguishes a hierarchical multiscale model from a standard recursive domain decomposition is the introduction of simplifying assumptions in, for instance, the equations that govern the behavior of each domain under external actions. In the "classical" physical modeling paradigm, simplifying assumptions are usually derived from empirical observations and then introduced in the formulation after arduous analytical manipulations. Needless to say, this task requires a solid theoretical background in the corresponding discipline and, more often than not, a good dose of inspiration and creativity.

Luckily, introducing "physical insight-based" simplifications is not the only route for filtering out unnecessary complexity from a given computational model, multiscale or otherwise. In recent years, there has been a revival of interest in the so-called model-order reduction techniques. These techniques allow us to significantly simplify, in a systematic manner, a given computational model using the information obtained from representative full-order simulations. The goal of this presentation is to elucidate how these techniques can be harnessed to simplify a given multiscale hierarchical model. A classical composite laminate structural problem is used to convey the flavor of the proposed model order reduction strategy. The reader interested in plunging into the formalisms of the approach is referred to References [1] and [2].

REFERENCES

[1] JA Hernández, J Oliver, AE Huespe, MA Caicedo, and JC Cante. High-performance model reduction techniques in computational multiscale homogenization. Computer Methods in Applied Mechanics and Engineering, 276:149–189, 2014.

[2] J.A. Hernández, M.A. Caicedo and A. Ferrer, Dimensional finite element models via empirical cubature, Computer and Engineering, Vol. 313, 687–722,(2017).