New Methodologies for Reducing Size and Complexity of Large and Complex Engineering Systems

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ABSTRACT

In this work, a bit intellectually provocative, we will prove that despite of the apparent complexity that many large engineering systems exhibit, usually (always?) an intrinsic simplicity remains hidden to our eyes. For that purpose we will articulate our exposition throughout the following items:

- Most of system components can be reduced to a sort of parametric transfer function while keeping all their intrinsic physical richness. Those functions, as soon as they have been particularized for the parameters involved in their physics, allow computing from the component input, the component output. Thus, in opposition to standard PGD-based veademecums, here only the component is parameterized, without including into the parameters list the component inputs that in most circumstances cannot be expressed in a compact and reduced enough parametric form (inputs exhibiting combinatorial issues as for example loading trajectories, fields, …).
- Transfer functions can be easily connected one to other(s): the output of the former being the input of the last(s); and then the system can be easily modeled parametrically.
- The choice of parameters, number and nature, remains the trickiest issue. How to chose the minimum number of (uncorrelated) parameters (that can be a combination of those initially considered) being explicative enough to describe the smooth manifold of the output of interest under consideration, and at the same time be sure that no relevant parameter needed for describing the physics was forgotten.
- Sometimes parameters are too heterogeneous in nature, and therefore the construction of models remains a tricky issue. Sparse PGD circumvent that problem thanks to its inherent separated representation that avoids mixing variables of different nature when constructing the model. Other possibility consists of moving from a representation space to a metric space in which all constructions based on distances plenty recover their sense.
- Data is expensive to collect, expensive to cure and to assimilate (expensive in the sense of technological difficulties, e.g. expensive sensors and the difficulty of placing them everywhere, …) thus, the amount of data should remain as limited as possible, transforming the big-data context in a more valuable smart-data paradigm.

All this topics will be covered and integrated in some applications to prove the potential and great interest of that approach addressesing complexity within a very simple and efficient framework.