Special Session on

Computational engineering empowered by model order reduction and machine learning

Organizers

(in alphabetical order):

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Scientists and engineers aimed from the beginning to model systems and processes. In the last century this implied the resolution of initial and boundary valued problems (IBVP) were partial differential equations were involved. Thanks, both to the increasing capabilities of today's computers and to the improvement of numerical methods the number and the complexity of modeled problems have increased. This path, however, has two major drawbacks. First, it is inherently dependent on the computers capabilities and performance and, second; a large number of engineering problems (for instance, those defined in highly dimensional spaces) are, in any case, left as non-computable. Note also that, in any case, just brute-force computations will never be the solution for real-time modeling of complex engineering systems or processes.

Engineering has, from its origins, also sought for another approach to solve complex problems: putting a maximum of physical information into some key features describing the problem. Usually, this is done by *modeling*, the more inside on the inherent problem is involved in the modeling the less numerical resources are required. This justifies why today, in the 21st century, beam models in structural engineering or panel methods in aeronautical engineering remain unbeatable for everyday practice.

Moreover, a paradigm of "getting more for less" is when engineers are able to combine good modeling with mathematical tools aiming at putting a maximum of physical information into some key features describing the problem. The classical example is *modal analysis* for measuring and analyzing the dynamic response of structures and or fluids when excited by an input (which is a standard approach in automotive, naval, aeronautical or structural engineering). Mathematics allows constructing with a few "modes" a realistic model to obtain the desired engineering outputs (displacement at some points, stresses in sensitive areas, energy intensity factors, etc). Note, that thanks to model analysis, real-time engineering can be used in practice to control structures.

This session is aimed at grouping together all the Iberian groups working in model order reduction and machine learning in any field of engineering or applied sciences and to share experiences and developments. To this end, we encourage contributions on the following, non exclusive, list of topics:

- Proper Orthogonal Decompositions, Principal Component Analysis, or Karhunen-Loeve transforms.
- Proper Generalized Decompositions
- Reduced Basis, greedy algorithms and related techniques
- Singular value decompositions and their high-order counterparts
- Mathematical foundations of reduced-order modeling
- Real-time simulation and control

- High-dimensioanl problems, curse of dimensionality
- Large time increment techniques
- Physics-informed neural networks
- Machine learning applied to computational engineering and sciences
- …

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