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# REDUCED BASIS, POD AND PGD MODEL REDUCTION TECHNIQUES

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## ABSTRACT

Numerous models encountered in science and engineering remain nowadays, despite the impressive progresses attained recently in computational simulation techniques, intractable when the usual and well experienced discretization techniques are applied for their numerical simulation. Thus, different challenging issues are waiting for the proposal of new alternative advanced simulation techniques, the brute force approach being no more a valuable alternative.

A first challenging issue concerns the treatment of highly multidimensional models arising from quantum mechanics or kinetic theory models of solids or fluids, including micro and nano-structured complex fluids, stochastic problems and parametric models. The main challenge in the treatment of this kind of models is related to the curse of dimensionality because when one applies standard mesh based discretization the number of degrees of freedom involved scales exponentially with the dimension of the space concerned. By this reason the treatment of this kind of models is at present restricted to the ones defined in moderate multidimensional spaces where the sparse grid based methods work.

Another issue concerns the solution of transient multiscale models (usually strongly non linear and coupled, and always of high size). These models arise in computational mechanics (involving a large variety of constitutive behaviors, couplings etc.). In this context, the use of standard incremental discretization techniques becomes inefficient from the computational time viewpoint. In general, these models involve different characteristic times ranging through several decades. Moreover, in the context of problems optimization of inverse identification many direct problems must be solved. Again, alternative advanced computational techniques are urgently needed.

Many of these challenging issues can be addressed through various approaches to dimension reduction in state and parameter space. Examples of dimension reduction include separated representations in the framework of Proper Generalized Decompositions – PGD -, sparse grid techniques, reduced bases and model order reduction based on the Proper Orthogonal Decomposition – POD - for rapid and reliable approximation of ODE's and PDE's. However, when using any kind of reduced modeling, verification is a crucial point because we are introducing an inevitable error whose quantification is extremely important in engineering applications. Reduced Models could be also seen as a new generation of decision-making tools for online computation, in particular Virtual Charts for engineering design and optimization.

In the session, the most recent advances attained by the former techniques will be pointed out and new incipient alternatives explored.