11th World Congress on Computational Mechanics (WCCM XI)
5th European Conference on Computational Mechanics (ECCM V)
6th European Conference on Computational Fluid Dynamics (ECFD VI)
July 20–25, 2014, Barcelona, Spain

REDUCED-ORDER MULTIMODELING FOR ENGINEERING DESIGN

David Néron[1,2] and Hachmi Ben Dhia[2]

[1] LMT-Cachan (ENS Cachan/CNRS/UPMC/PRES UniverSud Paris)
61 avenue du Président Wilson, 94235 Cachan Cedex, France
neron@lmt.ens-cachan.fr
[2] MSSMat (ECP/CNRS)
Grande Voie des Vignes, 92295 Châtenay-Malabry Cedex, France
hachmi.ben-dhia@ecp.fr

Key words: *Model Reduction, PGD, Arlequin method, Multimodel, Coupling*

In engineering design, the numerical simulation of very large multiscale models is becoming increasingly important because of the need to describe realistic scenarios and to derive tools to facilitate the virtual design of new structures. However, the incredible evolution of computing resources over the last decade are struggling to counterbalance for the increasing complexity of the models that engineers want to address in their efforts to design, control and optimize innovative products. Solving problems with very large number of degrees of freedom, with the presence of multiscale and multiphysics aspects, or with the need to take account of uncertainties or parameter variations can not be handled by standard resolution techniques. In this context, model reduction methods have a huge potential to develop innovative tools for intensive computation and allow a “real time” interaction between the user and the simulations, which gives the opportunity to explore a large number of scenarios in the design office. Reduction methods based on the assumption of a separated form of the unknowns currently receive a huge interest in the field of Mechanical Engineering and in the Applied Mathematics community and this work focuses on the Proper Generalized Decomposition (PGD) which has been the core of a huge number of previous developments to deal efficiently, for example, with multiscale and multiphysics problems [1, 2].

However, to go step forward, a major issue which is addressed herein is the coupling of reduced-order models to mix several models within the same simulation. This would allow a considerable increase in the flexibility of resolution strategies and provide new opportunities in terms of design, such as: (i) the ability to consider a complete system as an assembly of components, each represented by its own model; (ii) the possibility of handling reduced models arising from several actors involved in the design of the same product; (iii) the ability to take into account the critical phenomena, which occur locally in time and space, with a finer numerical model that could be adapted automatically during the simulation; (iv) the flexibility to change some local data (geometry, topology, material, architecture ...) in order to change the global structure.

The issues of coupling reduced models are essentially the possibly different natures of the mathematical models to "marry" and the management of incompatibilities between the models (in terms of refinement, but also in terms of geometry). For this purpose, we propose to use the Arlequin technique [3] which applies to problems suitable to a division into several "zones" requiring different levels of analysis. The term "zones" should be understood in the broad-sense, as it concerns different numerical models whose fields can be mixed and glued together. For that, a superposition technique based on a weak formulation, in which the energy is distributed between the various models is used. This technique allows to deal easily with incompatible models, including the ones defined on different meshes. The Arlequin method has been the subject of many developments (see e.g. [4]) and showed its capabilities to locally refine models (zoom), link structure models (substructuring or external junction) and introduce an essential local modification in models (internal junction).

REFERENCES

[1] D. Néron and D. Dureisseix. A computational strategy for thermo-poroelastic structures with a time-space interface coupling. *International Journal for Numerical Methods in Engineering*, 75(9):1053–1084, 2008.

[2] P. Ladevèze, J.-C. Passieux, and D. Néron. The LATIN multiscale computational method and the Proper Generalized Decomposition. *Computer Methods in Applied Mechanics and Engineering*, 199:1287–1296, 2010.

[3] H. Ben Dhia. Multiscale mechanical problems: the Arlequin method. *Comptes Rendus de l'Acadmie des Sciences*, 326 :899–904, 1998.

[4] H. Ben Dhia and G. Rateau. The Arlequin method as a flexible engineering design tool. *International Journal for Numerical Methods in Engineering*, 62:1442–1462, 2005.