NURBS-Enhanced Reduced Order Modelling with PGD

Xi Zou[*,†], Jean-Charles Passieux[‡], Michele Conti[*], Pedro Díez[†] and Ferdinando Auricchio[*]

[*] Dipartimento di Ingegneria Civile ed Architettura (DICAr)
Università degli Studi di Pavia
Via Ferrata 3, 27100 Pavia, Italy
e-mail: xi.zou@unipv.it; michele.conti@unipv.it; auricchio@unipv.it

[†] Laboratori de Càlcul Numèric (LaCàN)
Universitat Politècnica de Catalunya
c/ Jordi Girona 1-3, 08034 Barcelona, Spain
e-mail: pedro.diez@upc.edu

[‡] Institut Clément Ader
Institut National des Sciences Appliquées de Toulouse
3 rue Caroline Aigle, 31400 Toulouse, France
e-mail: passieux@insa-toulouse.fr

ABSTRACT

Proper generalized decomposition (PGD) is a powerful technique on tackling the so-called *curse of dimensionality* by means of reduced order modelling. Based on the idea of separation of variables, the parametric solution is assumed to have a separated representation, in order to reduce the multi-dimensional problem to a sum of tensor product of functions defined in lower dimensional subspaces. For example, frequently the multi-dimensional problem is separated as a sequence of mechanical problems solved in physical space and parametric problems solved in proper spaces. After the offline computation phase, PGD generates a computational vademecum which can be used in the subsequent online phase for different types of problems requiring multi-queries and/or extremely fast responses.

In this work, inspired by the benefits from IGA, we take advantage of NURBS shape functions for the discretization of the parametric space. In many cases, the parametric space is not Cartesian, thus has low separability. For example, when taking the loading location as extra-coordinates, the admissible locations may usually be a non-uniformly curved surface. Instead of separating the parametric space as a tensor product of 1D subspaces which may lead to non-physical solutions, we separate it into a tensor product of higher dimensional (2D or 3D) parametric subspaces which collect the highly correlated parameters. With NURBS, we are able to represent the parametric spaces exactly, and solve problems involving parametric spaces that have low separability due to constraints from physics, geometry or other aspects. Besides, the convergence rate is improved due to the smoothness of the NURBS shape functions in separated parametric subspaces.

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