Preface

This book is intended to make life easier to those interested in model order reduction techniques, and particularly in proper generalized decomposition (PGD) methods. We are aware that it looks often difficult to obtain a good PGD program and that there is a sort of steep learning curve. To overcome these difficulties, this book is thought to ease as much as possible the coding phase of PGD.

Many other books devoted to model order reduction in general, and PGD in particular, exist nowadays. But we strongly believe that this one covers aspects not fully considered in previous works on the topic.

Maybe the greatest advantage of PGD over other model reduction techniques, if any, relies in its ability of coping with parametric problems defined in high-dimensional *phase spaces*. This book begins with the most classical Poisson problem and soon moves to parametric problems in a wider sense. Among all the possible parametric problems, we have chosen some that can be considered *not classical*. Covered problems are not classical in the sense that we extend the concept of *parameter* far beyond the classical meaning of the word. Thus, we show that boundary conditions, and in particular loads, can be considered as parameters. In Chap. 3, we will show how the position of a load can be efficiently considered as a parameter under the PGD rationale, leading in fact to a very simple interactive program in which the user can play with a cantilever beam and see in real time its deformed configuration. Although the problem of obtaining a response surface for a moving load has traditionally been seen as inseparable or, in other words, nonreducible, we show that it can be effectively reduced under the PGD prism. In an offline phase of the methods functions or modes approximating the solution are computed, so as to allow in an online phase to obtain a response in real time.

In Chap. 4, we extend the previous development to the case of nonlinear problems, taking hyperelasticity as a model problem. Nonlinear problems continue to be a headache for model order reduction techniques, since they provoke the loss of the most part of the gains of model order reduction and every time the tangent stiffness matrix of the problem needs to be reassembled. In this chapter we show

how a very simple explicit linearization leads to a neat program, able to provide three-dimensional results under real-time constraints.

In Chap. 5 we turn the concept of parameter up a notch. Indeed, we show how initial and boundary-value problems can be effectively reduced under the PGD framework by considering the fields of initial conditions as parameters. But initial conditions are indeed magnitudes of infinite dimension, and therefore there is a need for subsequent reduction. After finite element discretization, a proper orthogonal decomposition is applied over some snapshots of problems similar to the one at hand. Then, with a minimal number of parameters, initial conditions can be considered effectively as new parameters of the model.

By taking solid dynamics as a model problem, we show that PGD gives a very practical response for initial and boundary-value problems. These approaches have rendered impressive gains in terms of computational cost, allowing for real-time applications infields such as virtual surgery, among others.

We are confident that the reader will find his or her problem of interest represented by any of the chosen examples and that the accompanying Matlab codes will make his or her life easier.

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