

Preface

The goal of this book is to present a modern approach to inverse analyses (IA) that combines traditional framework with numerical techniques used for model reduction. In the main focus are parameter characterization problems in structural mechanics, although most of the material is applicable with slight modifications also to other scientific and engineering fields. The book is intended for engineers and scientist who would like to learn, up to the very details, how to bring together all the necessary pieces into working programs that will solve given inverse problem.

Since the main emphasis was on the implementation, selected algorithms are described into the details required for their implementation, and for all of them practical codes within MATLAB programming language are given with full listings. The codes are written in general way, so it shouldn't be difficult to translate them into any other programming language.

An inverse analyses procedure puts together experimental mechanics, numerical modeling and mathematical programming. For a successful IA procedure one needs to tackle all of these problems. In the structural context discussed in this book, with a traditional approach, simulations of the experiments are done by finite element modeling (FEM), and most frequently commercial codes are used for this purpose. In the problems, tackled within the book, that used this approach to IA a commercial code ABAQUS was selected, while the routines that are written to automatically modify FE models and run the simulations are presented and discussed.

As far as mathematical programming is concerned, given the objective of the book, the most popular optimization algorithms are selected and described up to the details of their successful implementation, while detailed theoretical background descriptions were omitted. Nevertheless, an attempt was made to guide interested readers for useful further readings on the given topics. Optimization algorithms are treated in Chap. 2, and the material in this chapter should serve for the reader to become familiar with all the main concepts of iterative optimization algorithms. The author strongly believes that, after reading this chapter, a careful reader will be

able to write his own program that solves numerically an optimization problem by using any of the algorithms discussed in the chapter.

Model reduction technique presented in this book is based on Proper Orthogonal Decomposition (POD) and Radial Basis Functions (RBF). In Chap. 3 it is explained up to very details how these two mathematical techniques are combined into a powerful computing tool that can have an accurate computation of system responses in a computing times shorter by few orders of magnitude with respect to traditional numerical modeling techniques used in structural context (e.g. FE modeling). The construction of proper orthogonal basis in the discrete theory approach was discussed in details, and three different derivations are presented and illustrated with simple examples. The objective of this chapter was to connect the ideas behind the POD theory to the present context and to show how the basic principles developed in different fields can be successfully used also in structural mechanics, and by author's opinion in many other computational problems.

The other mathematical tool used in this reduced basis model, namely RBF interpolation is also described in detailed manner and covered by numerical examples that should serve for a better understanding. Finally, in the last part of Chap. 3, it was demonstrated how the two techniques can be combined into a reduced model used for the computation of system responses in structural mechanics context. This chapter is written with the intentions to explain all the concepts on which reduced basis model here presented is built. The author's opinion is that the careful reader should be capable to, by applying the analogy, employ the described model also to other physical phenomena.

In the last two chapters it was demonstrated how all the previous pieces are put together into a fully working inverse analysis procedure. Chap. 4 showed all the necessary steps for building a so-called traditional IA procedure, where FE simulations are used for the prediction of the system responses. Even though the book presented a modern approach to the inverse analyses, where a reduced basis models should be used for the prediction of system responses, by author's opinion also the traditional approach is very important as it anyhow should be used in some stages of the development. Since the main accent of the book was on the implementation, also in this chapter a detailed description of all the necessary programs was discussed and the developed codes are given in full listings. The material presented in this chapter should be enough for the reader to become familiar with all the elements of practical IA procedure. In the chapter two different case studies are considered that should be used as guidelines for any other similar problem. From this chapter readers should learn how to write from the very beginning a fully working inverse analyses procedure in the structural context by coupling MATLAB routines with commercial FEM code ABAQUS.

Finally, in Chap. 5 of the book it was shown how to incorporate the developed reduced basis model into an inverse analysis procedure. With a fast computational tool like the one developed in Chap. 3, inverse analysis becomes fast and robust. This feature was demonstrated in the examples treated in this chapter. It is shown how to build standalone software which, once that it is calibrated for a given experiment, can be further routinely used on a fast and effective way.

Author believes that the selected material presented in this book should be enough to introduce the readers to the problems encountered in the inverse analysis field. The examples treated in the book should help for a better understanding of all the presented concepts. Author hopes that the book will serve also as inspiration for many different applications of this fast growing scientific field.

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