

Preface

Identifying, modelling and controlling nonlinear vibrations is becoming increasingly important in a range of engineering applications. This is particularly true in the design of flexible structures such as aircraft, satellites, bridges, sports stadia and other tall/slender structures. There are also applications in the areas of robotics, mechatronics, micro-electro-mechanical systems (MEMS) and non-destructive testing (NDT) and related disciplines such as structural health monitoring (SHM).

In the majority of cases, the trend is towards lighter structures, increased flexibility and other higher levels of performance requirements. It is increasingly common for structures to have integrated actuator and sensor networks to carry out tasks such as limiting unwanted vibrations, detecting damage and in some cases changing the shape of the structure. These types of structures have become known as *smart structures* (sometimes called adaptive or intelligent structures). They are often made of new composite materials and their ability to perform multiple tasks means that these types of smart structures are *multifunctional*.

Nonlinear behaviour in structural dynamics arises naturally from a range of common material and geometric non-linearities. By their nature, these structures are typically made up of highly flexible continuous elements such as beams, cables and plates. They are also required to operate in a dynamic environment and, as a result, understanding the vibration behaviour of the structures is critically important.

The focus of this book is first to give a comprehensive treatment of nonlinear multi-modal structural vibration problems, and then to show how (a limited set of) control techniques can be applied to such systems. The emphasis is on continuous structural elements with relatively simple geometry, which enables a range of analytical and approximate techniques to be presented, without the need for extensive numerical simulation. It should be emphasized that there is no attempt to provide a comprehensive treatment of nonlinear control techniques in this book. Instead, a limited set of control approaches which apply to problems of *vibration control* are presented.

The aim was to make the book accessible to the reader with some background knowledge in linear vibration. The book falls into two main parts. The first five chapters have been developed from lecture notes taught at masters level, and

example problems are included at the ends of Chaps. 2–4. The second half of the book, Chaps. 5–8, has more of a research emphasis, with case studies and research examples shown where appropriate.

Chapters 1–3 contain introductory material on nonlinear vibration phenomena and control methods for nonlinear vibration. Chapter 4 introduces the approximate techniques such as harmonic balance, and perturbation methods which can be used for analysis of nonlinear vibration problems. The topic of modal analysis for nonlinear structures is discussed in detail in Chap. 5. In particular, normal form analysis is used to model multi-modal vibration response for nonlinear structures.

Then each of Chaps. 6–8 is dedicated to a particular type of structural element. Chapter 6 is focused on beams, Chap. 7 on cables and Chap. 8 on plates and shells. In these chapters, a selection of nonlinear vibration case studies is presented. Discussions of control methods are also included where appropriate.

Since the first edition of this book was published, there has been continued interest in modelling and controlling nonlinear vibrations. The main change we have introduced is that the normal form methods described in Chaps. 4 and 5 are now based on the second order form of the governing equations. This is a more natural approach for structural dynamics problems and has other advantages that are explained in the relevant sections. In addition to this, many more minor additions have been made to update the text.

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