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Book review

Nonlinearity in Structural Dynamics: Detection, Identification and Modelling by K. Worden and G.R. Tomlinson, Institute of Physics Publishing, UK, 2001, pp xix +659, price £ 85.00, ISBN 0-7503-0356-5

This book provides an important contribution to the challenging world of non-linear structural dynamics and mechanical vibration. Focus of this book is on the detection, identification and modelling of non-linear elements such as the continuous or discontinuous non-linear springs, and dry (Coulomb) friction or non-linear dampers. Theoretical (such as the Duffing's oscillator), experimental (such as the impacting beam type laboratory experiment) and real world (such as a vehicle shock absorber) examples are considered to illustrate the fundamental concepts and procedures. Semi-analytical and computational modelling steps, as well key identification procedures, are adequately covered, along with typical time and frequency domain responses of simple and advanced systems.

As most researchers know, the subject of non-linear structural dynamics is rather vast and there is a substantial body of literature on this topic though many issues are yet to be adequately understood and many real-life non-linearities have never been fully examined. Consequently, it is very difficult to cover all of the relevant analytical, experimental, dynamic response and signal processing issues in one book. Therefore, some choices must be made in terms of what to include and exclude. Worden and Tomlinson list their reasons on p. xvi of Preface, and alert the reader that "this book is inevitably biased towards those areas which the authors are most familiar with…". For example, the application of the Hilbert transforms is well covered since the authors have done some pioneering research on this topic.

Contents include the following, logically structured chapters: 1. Linear systems, 2. From linear to non-linear, 3. FRFs of non-linear systems. 4. The Hilbert transform—a practical approach, 5. The Hilbert transform—a complex analytical approach, 6. System identification—discrete-time, 7. System identification—continuous-time, 8. The Volterra series and higher-order frequency response functions, and 9. Experimental case studies. In particular, the last chapter (9) is fascinating as it describes the results of several laboratory measurements, along with an application of theory presented in earlier chapters. Results clearly demonstrate the need for detecting and modelling various non-linearities. Appendices (from A to K) provide tutorials on probability theory, theorems for the Hilbert transform, advanced least-squares method, neural networks, Chebyshev polynomials, differentiation and integration of measured time data, Volterra kernels, random vibration and the like. The subject index (pp. 655–659) is quite useful as I have already looked up several topics on non-linear damping and hysteresis. Sample contents (from Chapters 1–3) could be viewed at <http://bookmarkphysics.iop.org/bookpge.htm?ID=845iN5a9kHlVRiglirSj5ReA&book=295h>

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One of the most interesting features of this book is the perfect balance the authors have provided, between computational and experimental methods, and between theory and practical applications. The writing style allows one to follow the material easily though I would have liked to see a list of commonly used symbols and abbreviations. One could go from the basic concepts to modern analyses or experiments. Some readers would, however, require advanced mathematical background to fully understand some topics. Yet another strong point of this book is the listing of 289 references including some well-known books, research papers and lecture notes on non-linear vibrations and related subjects. Worden and Tomlinson cite references throughout the book, and this should allow the reader to find more details, even on those subjects that are not explicitly addressed by this book.

The reviewer strongly recommends this book to researchers (in engineering and sciences) and practicing engineers (in aerospace, civil, and mechanical industries) who are actively investigating the role of non-linearities in structural and mechanical systems. It could be used as a supplementary or reference text for graduate and undergraduate students in this field. Lack of exercises at the end of chapters could preclude its usage as a primary text. Nonetheless, I congratulate the authors for writing this book as it is full of information, and it is an excellent reference for anyone conducting tests on non-linear structures and then constructing a dynamic model of the system.

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