Finite-element-model Updating Using Computional Intelligence Techniques

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Applications to Structural Dynamics

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Foreword

Finite-element modeling in this book is viewed as the mathematical and numerical process through which a physical structure is translated into a mathematical model and from that mathematical model a numerical procedure is used to estimate such dynamic characteristics as mode shapes and natural frequencies. Finite-element updating is a process through which such models are tuned to better reflect the measured data.

In this book, the Nelder–Mead simplex and Broyden–Fletcher–Goldfarb–Shanno (BFGS) optimization methods are introduced, applied and compared for finite-element-model updating. The use of reduction and expansion methods to equate measured modal data to finite-element systems matrices is also investigated. Furthermore, genetic algorithms are introduced and applied to finite-element-model updating.

The particle-swarm optimization method is also introduced and applied for finite-element-model updating and the results are compared to those obtained from the genetic algorithm. Furthermore, simulated annealing is also introduced and applied to finite-element-model updating and the results are compared to those from particle-swarm optimization. To deal with the issue of computational efficiency, a response-surface method that combines the multi-layer perceptron and particle-swarm optimization is introduced and applied to finite-element-model updating. The results are compared to those from genetic algorithm, particle-swarm optimization and simulated annealing.

To exploit the combined advantages of different optimization methods, a hybrid optimization method is introduced that combines particle-swarm optimization, with the Nelder–Mead simplex method and it is applied to finite-element-model updating. The results are compared to those from when genetic algorithm, particle-swarm optimization and simulated annealing are used individually.

Furthermore, a multi-objective optimization method that uses both modal properties data and frequency-domain data is introduced for finite-element-model updating. In addition, the multi-layer perceptron network is used for finite-element-model updating.

To bring the finite-element-model updating procedure onto firm statistical grounds, a Bayesian approach is applied. To illustrate the use of finite-element

updating, an application of this procedure for damage detection in structures is conducted. Finally, the book concludes with key recommendations and outstanding issues for further development.

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Preface

Finite-element-model Updating Using Computational Intelligence Techniques introduces the concepts of computational intelligence for finite-element-model updating. Finite-element modeling is a subject that has received acceptance and has applications in various disciplines of engineering including aerospace, civil, mechanical and electrical engineering. These finite-element models, however, do not necessarily predict the measured data sufficiently accurately. Because of this, there is a need for these models to be updated to better reflect the measured data.

This book introduces computational intelligence techniques to update finite-element models. The computational intelligence methods used for finite-element-model updating include neural networks, genetic algorithms, particle-swarm optimization, simulated annealing, response-surface methods, hybrid methods and Bayesian methods. Applications to engineering problems are considered especially for updating of finite-element models and its application to damage detection.

This book makes an interesting read and it will open up new avenues in the use of computational intelligence techniques to the problem of finite-element-model updating.

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