Structural Sensitivity Analysis And Optimization 2 Nonlinear Systems And Applications 1st Edition

Herbert Hornlein, Klaus Schittkowski The finite element method (FEM) has been used successfully for many years to simulate and analyse mechanical structural problems. The results are accepted or rejected by means of comparison of state variables (stresses, displacements, natural frequencies etc.) and user requirements. In further analyses the design variables will be updated until the user specifications are met and the design is feasible. This is the primary aim of the design process. On this set of feasible designs, the additional requirement given by an objective function (e.g. weight, stiffness, efficiency, etc.) defines the structural optimization problem. In recent years more and more finite element based analysis systems were ex tended and offer now optimization modules. They proceed from the design model as defined for structural analysis, to perform an internal adaption of design pa rameters based on formal mathematical methods. Despite of many common features, there are significant differences in the selected optimization strategy, the current implementation and the numerical results.

Optimization methods are perceived to be at the heart of computer methods for designing engineering systems. With

these optimization methods, the designer can evaluate more alternatives, resulting in a better and more cost-effective design. This guide describes the use of modern optimization methods with simple yet meaningful structural design examples. Optimum solutions are obtained and, where possible, compared with the solutions obtained using traditional design procedures.

A Preliminary Study of Sensitivity Analysis and Its Applications to Structural Control Problems

Reliable Structural Optimization with Error Estimation, Adaptivity and Robust Sensitivity Analysis

Stability and Optimization of Structures

Sensitivity Analysis and Optimization in Nonlinear Solid Mechanics

The book is organized into four chapters. The first three treat distinct types of design variables, and the fourth presents a built-up structure formulation that combines the other three. The first chapter treats finite-dimensional problems, in which the state variable is a finite-dimensional vector of structure displacements and the design parameters. The structual state equations are matrix equations for static response, vibration, and buckling of structures and matrix differential equations for transient dynamic response of structures, which design variables appearing in the coefficient matrices. Advances in Structural Optimization presents the techniques for a wide set of applications, ranging from the problems of size and shape optimization

(historically the first to be studied) to topology and material optimization. Structural models are considered that use both discrete and finite elements. Structural materials can be classical or new. Emerging methods are also addressed, such as automatic differentiation, intelligent structures optimization, integration of structural optimization in concurrent engineering environments, and multidisciplinary optimization. For researchers and designers in industries such as aerospace, automotive, mechanical, civil, nuclear, naval and offshore. A reference book for advanced undergraduate or graduate courses on structural optimization and optimum design.

Shape Sensitivity Analysis

Mathematical Modeling and Optimization of Complex Structures

Advances in Structural Optimization

Elements of Structural Optimization

The Feature-Driven Method for Structural Optimization details a novel structural optimization method within a CAD framework, integrating structural optimization and feature-based design. The book presents cutting-edge research on advanced structures and introduces the feature-driven structural optimization method by regarding engineering features as basic design primitives. Consequently, it presents a method that allows structural optimization and feature design to be done simultaneously so that feature attributes are preserved throughout the design process. The book illustrates

and supports the effectiveness of the method described, showing potential applications through numerical modeling techniques and programming. This volume presents a high-performance optimization method adapted to engineering structures—a novel perspective that will help engineers in the computation, modeling and design of advanced structures. Integrates two independent methods - structural optimization and feature-based design—into one framework Adapts the high performance optimization method to the practice of designing engineering structures Provides numerical evidence for the effectiveness and potential of the methods described Works within a computer-aided design framework to develop a novel structural optimization methodology Presents engineering features as the basic design primitives in structural optimization

This report presents a preliminary study of the sensitivity analysis for dynamic systems with emphasis on its applications to structural control. Definitions are first given for different sensitivity functions in the time and the frequency domains. Since most physical quantities of dynamic systems cannot be expressed in analytical forms, we introduce an indirect approach to determine their sensitivity derivatives from the sensitivity equations derived from governing equations. A direct application of the sensitivity analysis can be found in the integrated control and optimization in which design variables and control variables are treated equally as the system parameters active in optimization. An extensive review and evaluation of the existing techniques in this area are given to identify a feasible algorithm for future improvements. Finally, a new control algorithm, called optimization based instant control, is proposed for those systems subjected to general

deterministic or random excitations. Unlike the conventional algorithm, the optimal control is designed and implemented according to instant information of the excitations. The important feature of this approach is that the original optimal control becomes a problem of static parameter optimization. The formulation layout makes it possible to apply the newly developed compound scaling algorithm in optimal structural control.

Structural Sensitivity Analysis: Methods, Applications and Needs

An Introduction to Structural Optimization

Implementation of Global Sensitivity Analysis in Dual Structural/control Optimization

Optimization of Large Structural Systems

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The field of structural optimization is still a relatively new field undergoing rapid changes in methods and focus. Until recently there was a severe imbalance between the enormous amount of literature on the subject, and the paucity of applications to practical design problems. This imbalance is being gradually redressed now. There is still no shortage of new publications, but there are also exciting applications of the methods of structural optimizations in the automotive, aerospace, civil engineering, machine design and other engineering fields. As a result of the growing pace of applications, research into structural optimization methods is increasingly driven by real-life problems. Most engineers who design structures employ complex general-purpose software packages for structural analysis. Often they do not have any access to the source the details of program, and even more frequently they have only scant knowledge of the structural

analysis algorithms used in this software packages. Therefore the major challenge faced by researchers in structural optimization is to develop methods that are suitable for use with such software packages. Another major challenge is the high computational cost associated with the analysis of many complex real-life problems. In many cases the engineer who has the task of designing a structure cannot afford to analyze it more than a handful of times.

Introduction to Shape Optimization

Analysis and Optimization of Prismatic and Axisymmetric Shell Structures

Linear Systems

Shape Design Sensitivity Analysis and Optimization Using the Boundary Element Method

This report presents an iterative method for optimal design of large scale structures that incorporates the concept of substructuring. Design sensitivity analysis for the method is developed in a state space setting, in which the symmetry of the structural stiffness matrix is utilized to define efficient adjoint calculations that yield explicit design derivatives. The entire procedure is then presented as a convenient computational algorithm. Applications of the method are given for optimal design of two and three dimensional truss, idealized wing, and framed structures. Computer programs based on the present algorithm are presented for three truss structures (10 member plane cantilever truss, 200 member plane truss, 63 member space truss), three idealized wing structures (18 element wing box beam, 39 element rectangular wing, 150 element swept wing), and three framed structures (one-bay two-story plane frame, two-bay six-story plane frame, 48 element

space frame). Results obtained with the substructing formulation are compared first with results obtained without substructing and then with results obtained with other methods.

Extensive numerical methods for computing design sensitivity are included in the text for practical application and software development. The numerical method allows integration of CAD-FEA-DSA software tools, so that design optimization can be carried out using CAD geometric models instead of FEA models. This capability allows integration of CAD-CAE-CAM so that optimized designs can be manufactured effectively.

Nonlinear Systems and Applications

Integrated Computational Considerations for Large Scale Structural Design Sensitivity Analysis and Optimization

Structural Optimization and Sensitivity Analysis Using Finite Element Force Method

Shape Design Sensitivity Analysis and Optimization for 2-D Structural Components Under Mixed-mode Fracture Using Extended Finite Element Method and Level Set Method

This book investigates the various aspects of shape optimization of two dimensional continuum structures, including shape design sensitivity analysis, structural analysis using the boundary element method (BEM), and shape optimization implementation. The book begins by reviewing the developments of shape optimization, followed by the presentation of the mathematical

programming methods for solving optimization problems. The basic theory of the BEM is presented which will be employed later on as the numerical tool to provide the structural responses and the shape design sensitivities. The key issue of shape optimization, the shape design sensitivity analy sis, is fully investigated. A general formulation of stress sensitivity using the continuum approach is presented. The difficulty of the modelling of the ad joint problem is studied, and two approaches are presented for the modelling of the adjoint problem. The first approach uses distributed loads to smooth the concentrated adjoint loads, and the second approach employs the singu larity subtraction method to remove the singular boundary displacements and tractions from the BEM equation. A novel finite difference based approach to shape design sensitivity is pre sented, which overcomes the two drawbacks of the conventional finite difference method. This approach has the advantage of being simple in concept, and eas ier implementation. A shape optimization program for two-dimensional continuum structures is developed, including structural analysis using the BEM, shape design sensitiv ity analysis, mathematical programming, and the design boundary modelling.

G.I.N. Rozvany ASI Director, Professor of Structural Design, FB 10, Essen University, Essen, Germany Structural optimization deals with the optimal design of all systems that consist, at least partially, of solids and are subject to stresses and deformations. This inte grated

discipline plays an increasingly important role in all branches of technology, including aerospace, structural, mechanical, civil and chemical engineering as well as energy generation and building technology. In fact, the design of most man made objects, ranging from space-ships and long-span bridges to tennis rackets and artificial organs, can be improved considerably if human intuition is enhanced by means of computer-aided, systematic decisions. In analysing highly complex structural systems in practice, discretization is un avoidable because closed-form analytical solutions are only available for relatively simple, idealized problems. To keep discretization errors to a minimum, it is de sirable to use a relatively large number of elements. Modern computer technology enables us to analyse systems with many thousand degrees of freedom. In the optimization of structural systems, however, most currently available methods are restricted to at most a few hundred variables or a few hundred active constraints. Design Sensitivity Analysis of Structural Systems

Generalized Sensitivity Analysis
Sensitivity Analysis of Complex Coupled Systems
Extended to Second and Higher Order Derivatives

This book has grown out of lectures and courses given at Linköping University, Sweden, over a period of 15 years. It gives an introductory treatment of problems and methods of structural optimization. The three basic classes of geometrical - timization problems of

mechanical structures, i. e. , size, shape and topology op- mization, are treated. The focus is on concrete numerical solution methods for d- crete and (?nite element) discretized linear elastic structures. The style is explicit and practical: mathematical proofs are provided when arguments can be kept e- mentary but are otherwise only cited, while implementation details are frequently provided. Moreover, since the text has an emphasis on geometrical design problems, where the design is represented by continuously varying—frequently very many— variables, so-called ?rst order methods are central to the treatment. These methods are based on sensitivity analysis, i. e. , on establishing ?rst order derivatives for - jectives and constraints. The classical ?rst order methods that we emphasize are CONLIN and MMA, which are based on explicit, convex and separable appro- mations. It should be remarked that the classical and frequently used so-called op- mality criteria method is also of this kind. It may also be noted in this context that zero order methods such as response surface methods, surrogate models, neural n- works, genetic algorithms, etc. , essentially apply to different types of problems than the ones treated here and should be presented elsewhere. This volume contains selected papers in three closely related areas: mathematical modeling in mechanics, numerical analysis, and optimization methods. The papers are based upon talks presented on the International Conference for Mathematical Modeling and Optimization in Mechanics, held in Jyväskylä, Finland, March 6-7,

2014 dedicated to Prof. N. Banichuk on the occasion of his 70th birthday. The articles are written by well-known scientists working in computational mechanics and in optimization of complicated technical models. Also, the volume contains papers discussing the historical development, the state of the art, new ideas, and open problems arising in modern continuum mechanics and applied optimization problems. Several papers are concerned with mathematical problems in numerical analysis, which are also closely related to important mechanical models. The main topics treated include: * Computer simulation methods in mechanics, physics, and biology; * Variational problems and methods; minimization algorithms; * Optimal control problems with distributed and discrete control; * Shape optimization and shape design problems in science and engineering; * Sensitivity analysis and parameters optimization of complex systems.

Design Sensitivity Analysis and Optimization of High Frequency Structural-acoustic Problems Using Energy Finite Element Method and Energy Boundary Element Method

Structural Sensitivity Analysis and Optimization 2

Guide to Structural Optimization

Substructuring Methods for Design Sensitivity Analysis and Structural Optimization

This book focuses on the optimization of a geometrically-nonlinear structure under stability constraint. It presents

a deep insight into optimization-based and computer-assisted stability design of discrete structures. Coverage combines design sensitivity analysis developed in structural optimization and imperfection-sensitivity analysis developed in stability analysis. Shell-type structures can be found almost everywhere. They appear in natural forms but also as man-made, load-bearing components in diverse engineering systems. Mankind has struggled to replicate nature's optimization of such structures but using modern computational tools it is now possible to analyse, design and optimise them systematically. Analysis and Optimization of Prismatic and Axisymmetric Shell Structures features: comprehensive coverage of the background theory of shell structures; development and implementation of reliable, creative and efficient computational tools for static and free-vibration analysis and structural optimization of variable-thickness shells and folded-plate structures; integrated computer-aided curve and surface modelling tools and automatic

mesh generation, structural analysis sensitivity analysis and mathematical programming methods; well-documented, downloadable Fortran software for these techniques using finite element and finite strip simulations which can be readily adapted by the reader for the solution of practical problems or for use within a teaching or research environment. Written by leading experts in finite element and finite strip methods, Analysis and Optimization of Prismatic and Axisymmetric Shell Structures will be of great interest to researchers in structural mechanics and in automotive, aerospace and civil engineering as well as to designers from all fields using shell structures for their strength-per-unit-mass advantages.

Investigating the Method of Structural Topological Variations for Sensitivity Analysis and Design Optimization

The Feature-Driven Method for Structural Optimization

A Novel Sensitivity Analysis Method for High-fidelity Multidisciplinary Optimization of Aero-structural Systems

Theory, Practice and Software

This book is motivated largely by a desire to solve shape optimization prob lems that arise in applications, particularly in structural mechanics and in the optimal control of distributed parameter systems. Many such problems can be formulated as the minimization of functionals defined over a class of admissible domains. Shape optimization is quite indispensable in the design and construction of industrial structures. For example, aircraft and spacecraft have to satisfy, at the same time, very strict criteria on mechanical performance while weighing as little as possible. The shape optimization problem for such a structure consists in finding a geometry of the structure which minimizes a given functional (e. g. such as the weight of the structure) and yet simultaneously satisfies specific constraints (like thickness, strain energy, or displacement bounds). The geometry of the structure can be considered as a given domain in the three-dimensional Euclidean space. The domain is an open, bounded set whose topology is given, e. g. it may be simply or doubly connected. The boundary is smooth or piecewise smooth,

so boundary value problems that are defined in the domain and associated with the classical partial differential equations of mathematical physics are well posed. In general the cost functional takes the form of an integral over the domain or its boundary where the integrand depends smoothly on the solution of a boundary value problem.

Integrated Structural Shape Optimization Using Second-order Sensitivity Analysis and Optimization Methods

Structural Sensitivity Analysis and Optimization 1

Improving Engineering System Design by Formal Decomposition, Sensitivity Analysis, and Optimization

Developments in Structural Design Sensitivity Analysis and Optimization in the Center for Computer Aided Design 1980-1986