

# An Investigation of the Recent Developments in Reliability-based Structural Topology Optimization

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## Abstract

Optimizing a structure's topology involves finding the best possible distribution of material and connections within a given design space. It has a significant effect on its performance, which is why there has been a meteoric rise in the number of articles published on the topic over the last two decades. This work offers an investigation of reliability-based topology optimization of structures, in light of the recent development of several topology optimization techniques for both linear and nonlinear systems. Therefore, the emphasis of this study is on the latest advancements, enhancements, and applications of reliability-based topology optimization. This paper's primary objective is to provide an overview of the latest advancements in the reliability-based topology optimization of structures, with a particular emphasis on the recent improvement of integrating reliability-based design into the bi-directional evolutionary structural optimization (BESO) method, which accounts for the topological optimization of geometric and material nonlinearity as well as thermoelastic problems.

## Keywords

topology optimization, reliability-based design, BESO, geometrically nonlinear, elasto-plastic

## 1 Introduction

The goal of structural optimization is to find the structure that is the lightest, stiffest, strongest, and most frequency-resistant while still meeting certain requirements like volume, mass, and deflection [1]. At the moment, structural optimization can be split into three different subfields: size optimization, topology optimization, and shape optimization [2–4]. It is important to emphasize that the optimization of topology is distinct from the optimization of size and shape. In shape optimization, design variables are the values that determine the shape of the structure of a given topology. Size optimization uses the geometrical dimensions of structural components as design variables, such as the thickness and diameter of a predefined geometrical shape. Topology optimization (TO) finds the ideal material distribution, hole placement, shape, size, and connection in a design domain. It is the most generic structural optimization method and has no constraints on design domain size or boundary, giving engineers greater design flexibility and search space to find the best solution, particularly during early design [5].

In the presence of sources of uncertainty, the optimum performance attained using typical deterministic approaches for structure optimization problems in the actual world might be drastically diminished. Variations in applied loads, material properties, and manufacturing tolerances may be the cause of uncertainty [6–10]. When the uncertainty comes simply from the variable directions in which a load is applied, Csébfalvi [11] offered a novel metaheuristic technique, where the randomness of the load directions were treated as uncertain but constrained parameters. Besides, Csébfalvi [12] presented benchmark results by considering the worst load direction-oriented technique. Kaveh and Zaerreza [13] introduced a novel approach for reliability-based design optimization (RBDO) that takes into account unpredictable characteristics like applied loads and material properties. Considering that the suggested technique uses decoupled metaheuristic algorithms. Lógó [14] developed a novel kind of probabilistic optimum topology design approach for continuum-type structures with random load application points.

# Recent Developments In Structural Optimization

**H. Dardon, H. Fukuda, K.L. Reifsnider, G.  
Verchery**



## **Recent Developments In Structural Optimization:**

**Recent Developments in Structural Optimization** Structures Congress, 1986      **Recent Developments in Automatic Control Systems** Yuriy P. Kondratenko, Vsevolod M. Kuntsevich, Arkadii A. Chikrii, Vyacheslav F. Gubarev, 2023-01-30 This monograph provides an overview of the recent developments in modern control systems including new theoretical findings and successful examples of practical implementation of the control theory in different areas of industrial and special applications. Recent Developments in Automatic Control Systems consists of extended versions of selected papers presented at the XXVI International Conference on Automatic Control Automation 2020, October 13-15, 2020, Kyiv, Ukraine, which is the main Ukrainian Control Conference organized by the Ukrainian Association on Automatic Control, a national member organization of IFAC and the National Technical University of Ukraine Igor Sikorsky Kyiv Polytechnic Institute. This is the third monograph in the River Publishers series in Automation Control and Robotics based on the selected papers of the Ukrainian Control Conferences. Automation in particular: the first monograph, *Control Systems Theory and Applications 2018*, was published based on Automation 2017 and the second monograph, *Advanced Control Systems Theory and Applications*, was based on Automation 2018. The monograph is divided into three main parts: a) Advances in Theoretical Research of Control Systems; b) Advances in Control Systems Application; c) Recent Developments in Collaborative Automation. The chapters have been structured to provide an easy-to-follow introduction to the topics that are addressed, including the most relevant references so that anyone interested in this field can get started in the area. This book may be useful for researchers and students who are interested in recent developments in modern control systems: robust adaptive systems, optimal control, fuzzy control, motion control, identification, modelling, differential games, evolutionary optimization, reliability, control security, control intelligent robotics and cyber physical systems.

**Recent Developments in the Theory of Shells** Holm Altenbach, Jacek Chróścielewski, Victor A. Eremeyev, Krzysztof Wiśniewski, 2019-09-25 This book commemorates the 80th birthday of Prof. W. Pietraszkiewicz, a prominent specialist in the field of general shell theory. Reflecting Prof. Pietraszkiewicz's focus, the respective papers address a range of current problems in the theory of shells. In addition, they present other structural mechanics problems involving dimension-reduced models. Lastly, several applications are discussed, including material models for such dimension-reduced structures.

*Latest Developments in Civil Engineering* Krishna Kant Pathak, J. M. S. J. Bandara, Ramakant Agrawal, 2023-10-02 This book comprises select proceedings of the International Conference on Recent Advances in Civil Engineering (RACE 2022). The contents of this book focus on the recent advancements and innovations in the field of civil engineering and various related areas such as design and development of new sustainable and smart building materials, performance analysis and simulation of steel structures, design and performance optimization of concrete structures, structural engineering, geotechnical engineering, water resources engineering and hydraulics, transportation and bridge engineering, building services design, surveying and remote sensing engineering, management and

renewable energy This book serves as a useful reference to researchers and professionals in the field of civil engineering

**Recent Developments in Durability Analysis of Composite Systems** H. Dardon,H. Fukuda,K.L. Reifsnider,G.

Verchery,2022-01-26 The papers from these proceedings address experimental and analytical methods for the characterization and analysis of modern composite and adhesive systems They have been produced to provide understanding that can be used to design safe reliable engineering components Applied Mechanics Reviews ,1974 **New**

**Developments in Contact Problems** Peter Wriggers,Panagiotis Panatitopoulos,2014-05-04 The book gives an overview on formulation mathematical analysis and numerical solution procedures of contact problems In this respect the book should be of value to applied mathematicians and engineers who are concerned with contact mechanics *Scientific and Technical Aerospace Reports* ,1992-07 *Human-Computer Interaction. Theory, Design, Development and Practice* Masaaki

Kurosu,2016-07-04 The 3 volume set LNCS 9731 9732 and 9733 constitutes the refereed proceedings of the 18th International Conference on Human Computer Interaction HCII 2016 held in Toronto ON Canada in July 2016 The total of 1287 papers and 186 posters presented at the HCII 2016 conferences and were carefully reviewed and selected from 4354 submissions The papers thoroughly cover the entire field of Human Computer Interaction addressing major advances in knowledge and effective use of computers in a variety of application areas The volumes constituting the full 27 volume set of the conference proceedings *Recent Developments and the New Direction in Soft-Computing Foundations and Applications* Shahnaz N. Shahbazova,Janusz Kacprzyk,Valentina Emilia Balas,Vladik Kreinovich,2020-07-10 This book gathers authoritative contributions in the field of Soft Computing Based on selected papers presented at the 7th World Conference on Soft Computing which was held on May 29 31 2018 in Baku Azerbaijan it describes new theoretical advances as well as cutting edge methods and applications New theories and algorithms in fuzzy logic cognitive modeling graph theory and metaheuristics are discussed and applications in data mining social networks control and robotics geoscience biomedicine and industrial management are described This book offers a timely broad snapshot of recent developments including thought provoking trends and challenges that are yielding new research directions in the diverse areas of Soft Computing

*Intelligent Computational Paradigms in Earthquake Engineering* Nikos D. Lagaros,Yiannis Tsompanakis,2007-01-01 This book contains contributions that cover a wide spectrum of very important real world engineering problems and explores the implementation of neural networks for the representation of structural responses in earthquake engineering It assesses the efficiency of seismic design procedures and describes the latest findings in intelligent optimal control systems and their applications in structural engineering Provided by publisher Analytic Methods for Design Practice Gyung-Jin Park,2007-02-15 In the world of modern engineering rigorous and definite design methodologies are needed However many parts of engineering design are performed in either an ad hoc manner or based on the intuition of the engineer This is the first book to look at both stages of the design process conceptual design and detailed design and detail design methodologies

for every step of the design process Case studies show how practical design problems can be solved with analytic design methods This book is an excellent introduction to the subject The book s practical focus will make the book useful to practicing engineers as a practical handbook of design      Simulation-Driven Design by Knowledge-Based Response Correction Techniques Slawomir Koziel, Leifur Leifsson, 2016-05-13 Focused on efficient simulation driven multi fidelity optimization techniques this monograph on simulation driven optimization covers simulations utilizing physics based low fidelity models often based on coarse discretization simulations or other types of simplified physics representations such as analytical models The methods presented in the book exploit as much as possible any knowledge about the system or device of interest embedded in the low fidelity model with the purpose of reducing the computational overhead of the design process Most of the techniques described in the book are of response correction type and can be split into parametric usually based on analytical formulas and non parametric i e not based on analytical formulas The latter while more complex in implementation tend to be more efficient The book presents a general formulation of response correction techniques as well as a number of specific methods including those based on correcting the low fidelity model response output space mapping manifold mapping adaptive response correction and shape preserving response prediction as well as on suitable modification of design specifications Detailed formulations application examples and the discussion of advantages and disadvantages of these techniques are also included The book demonstrates the use of the discussed techniques for solving real world engineering design problems including applications in microwave engineering antenna design and aero hydrodynamics

*Reanalysis of Structures* Uri Kirsch, 2008-02-24 This book deals with various computational procedures for multiple repeated analyses reanalysis of structures and presents them in a unified approach It meets the need for a general text covering the basic concepts and methods as well as recent developments in this area To clarify the presentation many illustrative examples and numerical results are demonstrated Previous books on structural analysis do not cover most of the material presented here      **New Developments in Mining Engineering 2015** Genadiy Pivnyak, Volodymyr

Bondarenko, Iryna Kovalevska, 2015-12-18 This annual series of books includes scientific papers on mining profiles This volume presents multiple aspects of mining technology implementation in several aspects extraction of coal iron manganese uranium and other ores Capturing and utilization of coalbed methane by various methods including alternative ones safety measures in mining ecological aspects etc Specific attention is paid to intensification of mineral resources extraction processes by way of modernizing opening methods development and mining methods depending on mining geological conditions Experimental results of stress strain state rock massif forecast by means of computational experiments using recursive methods are also discussed Any mining operations should finally result in adequate recovery of land surface and utilization of mining wastes using various environmentally friendly methods thus sufficient attention is paid to this scientific trend Non traditional methods of minerals mining are becoming more topical and of higher demand in the modern society

Hence several papers chapters are devoted to underground coal gasification and its subsequent processes In addition extraction technologies of gas hydrate as a source of an abundant amount of natural gas are thoroughly examined in this book including implementation of gas hydrate technologies for mine methane utilizations with its following transportation in a solid state Furthermore attention is given to evaluation of economic efficiency of minerals mining by the proposed methods their ways of enrichment ecological aspects and the influence of mining production on the environment innovational logistic solutions at mining enterprises and also to perspectives of Ukraine s mining industry integration to the European standards

**Recent Developments and New Direction in Soft-Computing Foundations and Applications** Lotfi A. Zadeh, Ali M. Abbasov, Ronald R. Yager, Shahnaz N. Shahbazova, Marek Z. Reformat, 2016-05-25 This book reports on advanced theories and cutting edge applications in the field of soft computing The individual chapters written by leading researchers are based on contributions presented during the 4th World Conference on Soft Computing held May 25 27 2014 in Berkeley The book covers a wealth of key topics in soft computing focusing on both fundamental aspects and applications The former include fuzzy mathematics type 2 fuzzy sets evolutionary based optimization aggregation and neural networks while the latter include soft computing in data analysis image processing decision making classification series prediction economics control and modeling By providing readers with a timely authoritative view on the field and by discussing thought provoking developments and challenges the book will foster new research directions in the diverse areas of soft computing

**Evaluation of Global Bearing Capacities of Structures** G. Sacchi Landriani, J. Salencon, 2014-05-04 A synthetic presentation of the theory of yield design is illustrated by examples such as the stability analysis of reinforced soil structures and the resistance of long fiber reinforced composite materials The classical limit analysis theory when standard elastic perfectly plastic behaviour can be assumed yields a more precise assessment of the global bearing capacities of structures and makes optimal limit design possible Structural optimal design is also studied with respect to eigenvalues as well as Structural Topology and Design Optimization

**Computational Mechanics '88** S.N. Atluri, G. Yagawa, 2013-11-11 The aim of this Conference was to become a forum for discussion of both academic and industrial research in those areas of computational engineering science and mechanics which involve and enrich the rational application of computers numerical methods and mechanics in modern technology The papers presented at this Conference cover the following topics Solid and Structural Mechanics Constitutive Modelling Inelastic and Finite Deformation Response Transient Analysis Structural Control and Optimization Fracture Mechanics and Structural Integrity Computational Fluid Dynamics Compressible and Incompressible Flow Aerodynamics Transport Phenomena Heat Transfer and Solidification Electromagnetic Field Related Soil Mechanics and MHD Modern Variational Methods Biomechanics and Off Shore Structural Mechanics

International Journal of Vehicle Design , 1990

**Recent Trends in Cold-Formed Steel Construction** Cheng Yu, 2023-11-04 Recent Trends in Cold Formed Steel Construction Second Edition focuses on the application and use of this important construction

material In this updated edition new chapters take on these developments offering updates on cutting edge new technologies and design methods for using cold formed steel as a structural material and providing technical guidance on how to design and build sustainable and energy efficient cold formed steel buildings Sections introduce codes specifications and design methods provide computational analysis of cold formed steel structures examine the structural performance of cold formed steel buildings and review thermal performance acoustic performance fire protection floor vibrations and blast resistance Over the last few years there has been major breakthroughs for cold formed steel design with modular building applications now becoming more widely accepted Other scientific developments include research on system reliability applications AI machine learning and the use of high strength steel as well as new connection methods and changes in DSM codes Addresses building science issues and provides performance solutions for the design of cold formed steel buildings Provides guidance for using next generation design methods computational tools and technologies Edited by an experienced researcher and educator with significant knowledge on new developments in cold formed steel construction Covers new developments such as modular construction machine learning and code developments in Europe Australia and China

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