

IUTAM SYMPOSIUM ZAKOPANE/POLAND 1993

W. Gutkowski · J. Bauer (Eds.)

Discrete Structural Optimization



Springer-Verlag

Discrete Structural Optimization

Min-Wei Huang



Discrete Structural Optimization:

Discrete Structural Optimization W. Gutkowski, 2014-09-01

Discrete Structural Optimization Witold

Gutkowski, Jacek Bauer, 2013-03-07 The IUTAM Symposium on Discrete Structural Optimization was devoted to discuss optimization problems for which design variables may not be sought among continuous sets. Optimum sizing from lists of available profiles, segmentation as well as allocation and number of supports, sensors or actuators are good examples of such problems for which design variables may be chosen only from finite sets. The above problems are having not only important practical applications. They are also inspiring scientific research in the field of discrete applied mathematics. Among them are controlled enumeration methods, subgradient approach, genetic programming, multicriteria optimization, neural nets etc. Along with its tradition of promoting and supporting new important fields of research in mechanics and its application, General Assembly of IUTAM decided in 1990 to support the Symposium. It is worthy to note that this is the second IUTAM Symposium on structural optimization organized in Poland. The first one was held in Warsaw twenty years ago and was organized by Professors Sawczuk and Mroz. It was devoted mostly to problems with continuous design variables. The Symposium which gathered 40 participants from 12 countries was sponsored by several institutions listed below. However, support by IUTAM should be specially appreciated. It helped several scientists to contribute to the Symposium which otherwise would not attend the meeting.

Discrete Structural Optimization as a Sequential Decision Process Solved Using Deep Reinforcement Learning

Maximilian Edward Ororbia, 2023 Topology optimization is a mathematical framework that in general seeks to determine the optimal layout of material in a design domain. If the design variables are continuous then often sensitivities can be derived and used with gradient-based optimization techniques. However, for certain applications the design variables are inherently discrete, for example the design of steel structures that are constructed of standardized steel sections. This work focuses on the latter whereby the optimization of structures with discrete elements and discrete design variables is formulated as a sequential decision process solved using reinforcement learning (RL) and deep reinforcement learning (DRL) which has been shown to efficiently provide adept solutions to a variety of high-dimensional planning and learning problems. Hence, this work mathematically models the discrete optimization of planar structures including trusses and frames as a Markov decision process (MDP). By modeling discrete structural optimization as an MDP, the set of all feasible design solutions can be precisely represented and the MDP naturally but not exclusively accommodates discrete actions. Within this framing, the MDP states correspond to specific structural designs represented as finite graph configurations and the actions correspond to specific topological and parametric grammars that are applied to alter the structure, transitioning the design to a new state and graph configuration. Key to modeling discrete optimization as an MDP is the relation of the rewards to the change in the design's performance as the agent explores alternate design configurations. Through this relation, the agent learns an optimal policy that is a sequence of necessary alteration actions that maximizes its cumulative

reward and simultaneously synthesizes a high performing design solution if not the global optimal with respect to the specified design problem's objective and specified constraints. The discrete MDP model solved using RL and DRL is applied to the discrete optimization of planar truss and frame structures. To demonstrate the merit of the idea and because elements of the MDP tuple are unknown to the agent a priori, a tabular implementation of reinforcement learning RL, specifically a Q-learning algorithm, was employed to solve the MDP due to its strong convergence properties. However, for problems with high dimensional state and action spaces that is with a large set of feasible design solutions, the number of state visits required to converge to the optimal policy becomes intractable, a problem commonly referred to as the curse of dimensionality. Tabular RL algorithms can become inefficient for solving design problems with relatively large state and action spaces due to their memory limitation and need for an excessive number of experiences to learn the optimal policy. Hence, by extending the general discrete structural optimization MDP to be solved using DRL, a deep neural network architecture is specifically developed to approximate the state action value function such that the network has far fewer parameters than the cardinality of the state space of feasible design solutions. This enables the MDP framework to adeptly solve discrete topology optimization design problems with large state and action spaces. A benefit of the suggested method in comparison to other discrete optimization approaches is that the MDP framework is grounded in mathematics and is not dependent on the specifics of the structural model. The framework is evaluated in the context of the discrete structural optimization of planar trusses and frames with discrete elements and multiple discrete cross sectional areas, and its utility is investigated through several numerical examples each with different state space cardinalities. The objective of the design task is to determine both the layout of structural elements and the assignment of cross sectional areas that minimize the displacement at a specified node for a given external force, determined using either linear or nonlinear finite element analysis, subject to stability and volume constraints. In this work, both the agent's learned optimal policy and the resulting synthesized design solution are validated against the policy determined by using a state action value iteration dynamic programming algorithm, chosen for its strong convergence guarantees, and the global optimal design configuration identified from an exhaustive evaluation of all feasible design solutions, respectively. Also, through qualitative and quantitative comparison with other considered alternative methods, the MDP framework is observed to adeptly learn optimal policies that synthesize optimal design solutions with lower computational effort.

Discrete Structural Optimization Visarn Chanaratna, 1978 The Application of Discrete Programming Techniques in the Structural Optimization Mehmet Rifat Sağlam, 1976 Discretization Methods and Structural Optimization — Procedures and Applications Hans A. Eschenauer, Georg Thierauf, 2012-12-06

In recent years, the Finite Element Methods (FEM) were more and more employed in development and design departments as very fast working tools in order to determine stresses, deformations, eigenfrequencies, etc. for all kinds of constructions under complex loading conditions. Meanwhile, very effective software systems have been developed by various research teams, although some

mathematical problems e.g convergence have not been solved satisfactorily yet In order to make further advances and to find a common language between mathematicians and mechanics the Society for Applied Mathematics and Mechanics GAMM agreed on the foundation of a special Committee Discretization Methods in Solid Mechanics focussing on the following problems Structuring of various methods displacement functions hybrid and mixed approaches etc Survey of approach functions Lagrange Hermite polynomials Spline functions Description of singularities Convergence and stability Practical and theoretical optimality to all mentioned issues single and interacting One of the basic aims of the GAMM Committee is the interdisciplinary cooperation between mechanics mathematicians and users which shall be intensified Thus on September 22 1985 the committee decided to hold a seminar on Structural Optimization in order to allow an exchange of experiences and thoughts between the experts of finite element methods and those of structural optimization A GAMM seminar entitled Discretization Methods and Structural Optimization Procedures and Applications was held on October 5-7 1988 at the University of Siegen

Structural Optimization with Nonlinear and Discrete Programming Peiming Wu, 1986

Recent Advances in Optimal Structural Design Scott A. Burns, 2002-01-01 Sponsored by the Technical Committee on Structural Design of the Technical Administrative Committee on Analysis and Computation of the Technical Activities Division of the Structural Engineering Institute of ASCE This report documents the dramatic new developments in the field of structural optimization over the last two decades Changes in both computational techniques and applications can be seen by developments in computational methods and solution algorithms the role of optimization during the various stages of structural design and the stochastic nature of design in relation to structural optimization Topics include methods for discrete variable structural optimization decomposition methods in structural optimization state of the art on the use of genetic algorithms in design of steel structures conceptual design optimization of engineering structures topology and geometry optimization of trusses and frames evolutionary structural optimization design and optimization of semi rigid framed structures optimized performance based design for buildings multi objective optimum design of seismic resistant structures and reliability and cost oriented optimal bridge maintenance planning The book concludes with an extensive bibliography of journal papers on structural optimization published between 1987 and 1999

Algorithms for Mixed Continuous-discrete Variable Problems in Structural Optimization Min-Wei Huang, 1995

Structural Optimization of Discrete Systems Represented by Finite Elements Dietrich Hartmann, University of California, Berkeley. Structural Engineering Laboratory, 1984

A Genetic Algorithm for the Discrete Structural Optimization of Laminated Plates Eugeneý Potgieter, 1997

Discrete Variable Structural Optimization by the Complex Method P. G. van Bladel, 1989

Integrated Structural Optimization of Discrete Framelike Structures for Multiple Load Cases Philipp A. Wagenblast, 2000

Properties of Discrete Optima in Structural Optimization A. Cella, 1972

Constraint Handling in Cohort Intelligence Algorithm Ishaan R. Kale, Anand J. Kulkarni, 2021-12-26 Mechanical Engineering domain problems are

generally complex consisting of different design variables and constraints These problems may not be solved using gradient based optimization techniques The stochastic nature inspired optimization techniques have been proposed in this book to efficiently handle the complex problems The nature inspired algorithms are classified as bio inspired swarm and physics chemical based algorithms Socio inspired is one of the subdomains of bio inspired algorithms and Cohort Intelligence CI models the social tendencies of learning candidates with an inherent goal to achieve the best possible position In this book CI is investigated by solving ten discrete variable truss structural problems eleven mixed variable design engineering problems seventeen linear and nonlinear constrained test problems and two real world applications from manufacturing domain Static Penalty Function SPF is also adopted to handle the linear and nonlinear constraints and limitations in CI and SPF approaches are examined Constraint Handling in Cohort Intelligence Algorithm is a valuable reference to practitioners working in the industry as well as to students and researchers in the area of optimization methods

Harmony Search Algorithms for Structural Design Optimization Zong Woo Geem, 2009-09-30 Various structures such as buildings bridges and paved roads play an important role in our lives However these construction projects require large expenditures Designing infrastructure cost efficiently while satisfying all necessary design constraints is one of the most important and difficult tasks for a structural engineer Traditionally mathematical gradient based optimization techniques have been applied to these designs However these gradient based methods are not suitable for discrete design variables such as factory made cross sectional area of structural members Recently researchers have turned their interest to phenomenon mimicking optimization techniques because these techniques have proved able to efficiently handle discrete design variables One of these techniques is harmony search an algorithm developed from musical improvisation that has been applied to various structural design problems and has demonstrated cost savings This book gathers all the latest developments relating to the application of the harmony search algorithm in the structural design field in order for readers to efficiently understand the full spectrum of the algorithm's potential and to easily apply the algorithm to their own structural problems This book contains six chapters with the following subjects standard harmony search algorithm and its applications by Lee standard harmony search algorithm for steel frame design by Degertekin adaptive harmony search algorithm and its applications by Saka and Hasan ebi harmony particle swarm algorithm and its applications by Li and Liu hybrid algorithm of harmony search particle swarm and parameter calibration of viscoelastic and damage functions by Mun and Geem

Global and Discrete Programming Problems in Structural Optimization Albert Anne Groenwold, 1997 **Discrete Structural Optimization** Witold Gutkowski, Jacek Bauer, 1994-07-22 The IUTAM Symposium on Discrete Structural Optimization was devoted to discuss optimization problems for which design variables may not be sought among continuous sets Optimum sizing from lists of available profiles segmentation as well as allocation and number of supports sensors or actuators are good examples of such problems for which design variables may be chosen only from finite sets The above problems are having not only important

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Advances in Structural Optimization J. Herskovits, 2012-12-06 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

Robotic Systems and Autonomous Platforms Shawn M. Walsh, Michael S. Strano, 2018-10-11 Robotic Systems and Autonomous Platforms Advances in Materials and Manufacturing showcases new materials and manufacturing methodologies for the enhancement of robotic and autonomous systems Initial chapters explore how autonomous systems can enable new uses for materials including innovations on different length scales from nano to macro and large systems The means by which autonomous systems can enable new uses for manufacturing are also addressed highlighting innovations in 3D additive manufacturing printing of materials novel synthesis of multifunctional materials and robotic cooperation Concluding themes deliver highly novel applications from the international academic industrial and government sectors This book will provide readers with a complete review of the cutting edge advances in materials and manufacturing methodologies that could enhance the capabilities of robotic and autonomous systems Presents comprehensive coverage of materials and manufacturing technologies as well as sections on related technology such as sensing communications autonomy control and actuation Explores potential applications demonstrated by a selection of case studies Contains contributions from leading experts in the field

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