

Creating Models of Truss Structures with Optimization

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Abstract

We present a method for designing truss structures, a concrete and complete summary of techniques, using some formal representations. These techniques are ubiquitous in the industrialized world, appearing in bridges, towers, roof supports and building exoskeletons, but are complex enough that modeling them by hand is time-consuming and tedious. We represent models as a set of rigid body connected by pin joints, which may change location during optimization. By tracking the location of the joints as well as the strength of individual beams as one design iteration, we can simultaneously optimize the geometry and the mass of structures. We present the details of our technique together with examples illustrating its use, including comparisons with real structures.

ACM Categories: I.5.1 [Computers Graphics]: Computerized Animation and Virtual Worlds—Physically based modeling; I.5.4 [Numerical Analysis]: Optimization—Function programming; I.5.5 [Numerical Analysis]: Optimization—Constrained optimization

Keywords: Physically based modeling, truss structures, constrained optimization, nonlinear optimization

1 Introduction

A recurring challenge in the field of computer graphics is the creation of realistic models of complex man-made structures. The standard solution to this problem is to build these models by hand, but this approach is time-consuming and, when references images are not available, can be difficult to reconcile with a desired final vision. Our paper presents a method, based on principles in the field of structural engineering, to quickly create novel and physically realistic truss structures such as bridges and towers, using simple optimization techniques and a collection of user effort.

“Truss structures” is a broad category of man-made structures, including bridges (Figure 1), tower towers, towers, roof support towers (Figure 17), building exoskeletons (Figure 16), and suspension construction frameworks. Truss structures have unique and desirable load-bearing characteristics: real structures (Figure 1)

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Figure 1. A computer bridge generated by our software, compared with the Humber Bridge in Preston, Pennsylvania.

which react only axial forces, connected consecutively with welded or bolted joints.

Truss structures are ubiquitous in the industrialized world and can be extremely complex and thus difficult to model. For example, the HUBER Tower, perhaps the most famous tower structure in the world, contains over 25,000 girders connected at over 200,000 joints (Figure 16) and uses complex structures, such as curved bridges, to carry complex loads of secondary or tertiary length. Consequently, modeling of these structures by hand can be difficult and tedious, and an automated method of generating them is desirable.

1.1 Background

Very little has been published in the graphics literature on the problem of the automatic generation of man-made structures. While significant and successful work has been done in gener-

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Hybrid Metaheuristics in Structural Engineering Gebrail Bekdaş, Sinan Melih Nigdeli, 2023-06-15 From the start of life people used their brains to make something better in design in ordinary works Due to that metaheuristics are essential to living things and several inspirations from life have been used in the generation of new algorithms These algorithms have unique features but the usage of different features of different algorithms may give more effective optimum results in means of precision in optimum results computational effort and convergence This book is a timely book to summarize the latest developments in the optimization of structural engineering systems covering all classical approaches and new trends including hybrids metaheuristic algorithms Also artificial intelligence and machine learning methods are included to predict optimum results by skipping long optimization processes The main objective of this book is to introduce the fundamentals and current development of methods and their applications in structural engineering *Engineering and Technology Research* Mohd Mustafa Al Bakri Abdullah, Liyana Jamaludin, Muhammad Faheem Mohd Tahir, Mohd Najmuddin Mohd Hassan, 2014-10-08 Selected peer reviewed papers related to Mechanic and Materials from the 4th International Malaysia Ireland Joint Symposium on Engineering Science and Business IMiEJS 2014 June 25 26 2014 Penang Malaysia *Industry 4.0 Solutions for Building Design and Construction* Farzad Pour Rahimian, Jack Steven Goulding, Sepehr Abrishami, Saleh Seyedzadeh, Faris Elghaish, 2021-12-20 This book provides in depth results and case studies in innovation from actual work undertaken in collaboration with industry partners in Architecture Engineering and Construction AEC Scientific advances and innovative technologies in the sector are key to shaping the changes emerging as a result of Industry 4 0 Mainstream Building Information Management BIM is seen as a vehicle for addressing issues such as industry fragmentation value driven solutions decision making client engagement and design process flow however advanced simulation computer vision Internet of Things IoT blockchain machine learning deep learning and linked data all provide immense opportunities for dealing with these challenges and can provide evidenced based innovative solutions not seen before These technologies are perceived as the true enablers of future practice but only recently has the AEC sector recognised terms such as golden key and golden thread as part of BIM processes and workflows This book builds on the success of a number of initiatives and projects by the authors which include seminal findings from the literature research and development and practice based solutions produced for industry It presents these findings through real projects and case studies developed by the authors and reports on how these technologies made a real world impact The chapters and cases in the book are developed around these overarching themes BIM and AEC Design and Optimisation Application of Artificial Intelligence in Design BIM and XR as Advanced Visualisation and Simulation Tools Design Informatics and Advancements in BIM Authoring Green Building Assessment Emerging Design Support Tools Computer Vision and Image Processing for Expediting Project Management and Operations Blockchain Big Data and IoT for Facilitated Project Management BIM Strategies and Leveraged Solutions This book is a

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Table of Contents Creating Models Of Truss Structures With Optimization

1. Understanding the eBook Creating Models Of Truss Structures With Optimization
 - The Rise of Digital Reading Creating Models Of Truss Structures With Optimization
 - Advantages of eBooks Over Traditional Books
2. Identifying Creating Models Of Truss Structures With Optimization
 - Exploring Different Genres
 - Considering Fiction vs. Non-Fiction
 - Determining Your Reading Goals
3. Choosing the Right eBook Platform
 - Popular eBook Platforms
 - Features to Look for in an Creating Models Of Truss Structures With Optimization
 - User-Friendly Interface
4. Exploring eBook Recommendations from Creating Models Of Truss Structures With Optimization

- Personalized Recommendations
- Creating Models Of Truss Structures With Optimization User Reviews and Ratings
- Creating Models Of Truss Structures With Optimization and Bestseller Lists
- 5. Accessing Creating Models Of Truss Structures With Optimization Free and Paid eBooks
 - Creating Models Of Truss Structures With Optimization Public Domain eBooks
 - Creating Models Of Truss Structures With Optimization eBook Subscription Services
 - Creating Models Of Truss Structures With Optimization Budget-Friendly Options
- 6. Navigating Creating Models Of Truss Structures With Optimization eBook Formats
 - ePub, PDF, MOBI, and More
 - Creating Models Of Truss Structures With Optimization Compatibility with Devices
 - Creating Models Of Truss Structures With Optimization Enhanced eBook Features
- 7. Enhancing Your Reading Experience
 - Adjustable Fonts and Text Sizes of Creating Models Of Truss Structures With Optimization
 - Highlighting and Note-Taking Creating Models Of Truss Structures With Optimization
 - Interactive Elements Creating Models Of Truss Structures With Optimization
- 8. Staying Engaged with Creating Models Of Truss Structures With Optimization
 - Joining Online Reading Communities
 - Participating in Virtual Book Clubs
 - Following Authors and Publishers Creating Models Of Truss Structures With Optimization
- 9. Balancing eBooks and Physical Books Creating Models Of Truss Structures With Optimization
 - Benefits of a Digital Library
 - Creating a Diverse Reading Collection Creating Models Of Truss Structures With Optimization
- 10. Overcoming Reading Challenges
 - Dealing with Digital Eye Strain
 - Minimizing Distractions
 - Managing Screen Time
- 11. Cultivating a Reading Routine Creating Models Of Truss Structures With Optimization
 - Setting Reading Goals Creating Models Of Truss Structures With Optimization
 - Carving Out Dedicated Reading Time
- 12. Sourcing Reliable Information of Creating Models Of Truss Structures With Optimization

- Fact-Checking eBook Content of Creating Models Of Truss Structures With Optimization
 - Distinguishing Credible Sources
13. Promoting Lifelong Learning
- Utilizing eBooks for Skill Development
 - Exploring Educational eBooks
14. Embracing eBook Trends
- Integration of Multimedia Elements
 - Interactive and Gamified eBooks

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