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A Comparative Analysis of Multi-Criteria Decision-Making Methods and Normalization Techniques in Holistic Sustainability Assessment for Engineering Applications

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Abstract: The sustainability evaluation of engineering processes and structures is a multifaceted challenge requiring the integration of diverse and often conflicting criteria. To address this challenge, Multi-Criteria Decision-Making (MCDM) methods have emerged as effective tools. However, the selection of the most suitable MCDM approach for problems involving multiple criteria is critical to ensuring robust, reliable, and actionable outcomes. Equally significant is the choice of a proper normalization technique, which plays a pivotal role in determining the robustness and reliability of the results. This study investigates the impact of common MCDM tools on the decision-making process concerning diverse aspects of sustainability. It also examines how different normalization methods influence the final outcomes. Sustainability in this context is understood as a trade-off among five key dimensions: performance, environmental impact, economic impact, social impact, and circularity. The outcome of the MCDM process is represented by an aggregated metric, referred to as the Sustainability Index (SI). This index offers a comprehensive and robust framework for evaluating sustainability and facilitating decision-making when conflicting criteria are present. To assess the effects of implementing different MCDM and normalization choices on the sustainability assessment, a dataset from the aviation sector is employed. Specifically, a typical aircraft component is analyzed as a case study for holistic sustainability assessment, utilizing data that represent the various dimensions of sustainability mentioned above, for this component. Additionally, the study investigates the influence of initial data variations and weight variations within the MCDM process on the results. The results indicate that, overall, the different MCDM and normalization methods lead to similar outcomes when applied to the design alternatives. However, a deeper dive into the results reveals that the weighted sum method, when paired with min-max normalization, appears to be more appropriate, based on the use case involved for the present investigation, due to its robustness regarding small variations in the initial data and its sensitivity to large ones. This research underscores the critical importance of selecting appropriate MCDM tools and normalization methods to enhance transparency, robustness, reliability, and consistency of sustainability assessments within a holistic framework.

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Keywords: sustainability evaluation; Sustainability Index (SI); Multi-Criteria Decision-Making (MCDM); normalization methods; sensitivity analysis; aviation sector; holistic sustainability assessment; decision-making process; robustness and reliability; consistency of sustainability assessments

Multi Criteria Decision Making Methods A Comparative Study

Raghavan (Ram) Ramanan

Multi Criteria Decision Making Methods A Comparative Study:

Multi-criteria Decision Making Methods Evangelos Triantaphyllou,2013-03-09 Multi Criteria Decision Making MCDM has been one of the fastest growing problem areas in many disciplines The central problem is how to evaluate a set of alternatives in terms of a number of criteria Although this problem is very relevant in practice there are few methods available and their quality is hard to determine Thus the question Which is the best method for a given problem has become one of the most important and challenging ones This is exactly what this book has as its focus and why it is important The author extensively compares both theoretically and empirically real life MCDM issues and makes the reader aware of quite a number of surprising abnormalities with some of these methods What makes this book so valuable and different is that even though the analyses are rigorous the results can be understood even by the non specialist Audience Researchers practitioners and students it can be used as a textbook for senior undergraduate or graduate courses in business and engineering

[Multi-Criteria Decision Making Methods](#) Evangelos Triantaphyllou,2014-01-15 [Multi-Criteria Decision-Making Methods in Manufacturing Environments](#) Shankar Chakraborty,Prasenjit Chatterjee,Partha Protim

Das,2023-10-13 This book introduces the step by step processes involved in using MCDM methods starting from problem formulation model development and criteria weighting to the final ranking of the alternatives The authors explain the different MCDM methods that can be used in specific manufacturing environments The book explains the conceptual frameworks of how these methods are applied with special focus on their applicability and usefulness The authors begin with an introduction to multi criteria decision making followed by explanations of 29 MCDM methods and their applications The final sections of the book describe helpful normalization techniques and criteria weight measurement techniques The collection of diverse range of manufacturing applications and case studies presented here will aid readers in applying cutting edge MCDM methods to their own manufacturing projects As both a research and teaching tool this book encourages critical and logical thinking when applying MCDM methods for solving complex manufacturing decision making problems

Normalization of Multidimensional Data for Multi-Criteria Decision Making Problems Irik Z. Mukhametzyanov,2023-07-25 This book presents a systematic review of multidimensional normalization methods and addresses problems frequently encountered when using various methods and ways to eliminate them The invariant properties of the linear normalization methods presented here can be used to eliminate simple problems and avoid obvious errors when choosing a normalization method The book introduces valuable novel techniques for the multistep normalization of multidimensional data One of these methods involves inverting the normalized values of cost attributes into profit attributes based on the reverse sorting algorithm ReS algorithm Another approach presented is the IZ method which addresses the issue of shift in normalized attribute values Additionally a new method for normalizing the decision matrix is proposed called the MS method which ensures the equalization of average values and variances of attributes Featuring

numerous illustrative examples throughout the book helps readers to understand what difficulties can arise in multidimensional normalization what to expect from such problems and how to solve them It is intended for academics and professionals in various areas of data science computing in mathematics and statistics as well as decision making and operations

Multi-criteria Decision Making Methods with Bipolar Fuzzy Sets Muhammad Akram, Shumaiza, José Carlos Rodríguez Alcantud, 2023-05-21 This monograph discusses the theoretical and practical development of multicriteria decision making MCDM The main purpose of MCDM is the construction of systematized strategies for the optimisation of feasible options as well as the justification of why some alternatives can be declared optimal However at time we must make decisions in an uncertain environment and such inconvenience gives rise to a much more elaborate scenario This book highlights models where this lack of certainty can be flexibly fitted in and goes on to explore valuable strategies for making decisions under a multiplicity of criteria Methods discussed include bipolar fuzzy TOPSIS method bipolar fuzzy ELECTRE I method bipolar fuzzy ELECTRE II method bipolar fuzzy VIKOR method bipolar fuzzy PROMETHEE method and two tuple linguistic bipolar fuzzy Heronian mean operators This book is a valuable resource for researchers computer scientists and social scientists alike

Advances in Distributed Computing and Machine Learning Rashmi Ranjan Rout, Soumya Kanti Ghosh, Prasanta K. Jana, Asis Kumar Tripathy, Jyoti Prakash Sahoo, Kuan-Ching Li, 2022-07-27 This book includes a collection of peer reviewed best selected research papers presented at the Third International Conference on Advances in Distributed Computing and Machine Learning ICADCM 2022 organized by Department of Computer Science and Engineering National Institute of Technology Warangal Telangana India during 15 16 January 2022 This book presents recent innovations in the field of scalable distributed systems in addition to cutting edge research in the field of Internet of Things IoT and blockchain in distributed environments

Introduction to Sustainability Analytics Raghavan (Ram) Ramanan, 2018-07-04 The roles of corporate and public stewards and the nature of their social contract with society have been changing over the past two centuries and those changes have accelerated in recent decades Moreover with increasing focus on sustainability factors from the marketplace regulators investors financiers and consumers corporate sustainability disclosure is shifting from voluntary to vital Corporate and public stewards are now responsible for their performance and services from cradle to grave they must properly manage corporate social responsibility and integrate it into their global strategies rather than consider it as merely a moral obligation or a risk reputation management exercise Sustainability analytics the critical link between sustainability and business strategy helps professionals track trend and transform sustainability information into actionable insights across the value chain and life cycle to enhance their sustainability performance and its disclosure This book Introduction to Sustainability Analytics provides corporate and public stewards with a comprehensive understanding of how to determine which sustainability metrics are material to them and relevant to their business and how to incorporate them into corporate strategy resource allocation and prioritization Focusing on practical decision making needs it explains how to

value and prioritize initiatives and how to best allocate necessary resources through several real case studies and practical examples Features Examines pressing issues such as climate change water scarcity and environmental justice Explains how to develop a business case and global strategy for social responsibility Includes both corporate and public policy perspectives on sustainability economics Covers emerging regulations on sustainability disclosure and responsible investing

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Comparative Study of Multiple Criteria Decision Making Methods Martine Dupaicha,1985 **Comparative Study of Fuzzy Versus Deterministic Decision Making Techniques in Engineering Design** Farnaz Akhavi,2006 *Annual Meeting of the North American Fuzzy Information Processing Society-NAFIPS*. North American Fuzzy Information Processing Society. Annual Meeting,2005 SME Technical Paper Society of Manufacturing Engineers,2005

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Table of Contents Multi Criteria Decision Making Methods A Comparative Study

1. Understanding the eBook Multi Criteria Decision Making Methods A Comparative Study
 - The Rise of Digital Reading Multi Criteria Decision Making Methods A Comparative Study
 - Advantages of eBooks Over Traditional Books
2. Identifying Multi Criteria Decision Making Methods A Comparative Study
 - 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 Multi Criteria Decision Making Methods A Comparative Study
 - User-Friendly Interface
4. Exploring eBook Recommendations from Multi Criteria Decision Making Methods A Comparative Study
 - Personalized Recommendations
 - Multi Criteria Decision Making Methods A Comparative Study User Reviews and Ratings

- Multi Criteria Decision Making Methods A Comparative Study and Bestseller Lists
- 5. Accessing Multi Criteria Decision Making Methods A Comparative Study Free and Paid eBooks
 - Multi Criteria Decision Making Methods A Comparative Study Public Domain eBooks
 - Multi Criteria Decision Making Methods A Comparative Study eBook Subscription Services
 - Multi Criteria Decision Making Methods A Comparative Study Budget-Friendly Options
- 6. Navigating Multi Criteria Decision Making Methods A Comparative Study eBook Formats
 - ePUB, PDF, MOBI, and More
 - Multi Criteria Decision Making Methods A Comparative Study Compatibility with Devices
 - Multi Criteria Decision Making Methods A Comparative Study Enhanced eBook Features
- 7. Enhancing Your Reading Experience
 - Adjustable Fonts and Text Sizes of Multi Criteria Decision Making Methods A Comparative Study
 - Highlighting and Note-Taking Multi Criteria Decision Making Methods A Comparative Study
 - Interactive Elements Multi Criteria Decision Making Methods A Comparative Study
- 8. Staying Engaged with Multi Criteria Decision Making Methods A Comparative Study
 - Joining Online Reading Communities
 - Participating in Virtual Book Clubs
 - Following Authors and Publishers Multi Criteria Decision Making Methods A Comparative Study
- 9. Balancing eBooks and Physical Books Multi Criteria Decision Making Methods A Comparative Study
 - Benefits of a Digital Library
 - Creating a Diverse Reading Collection Multi Criteria Decision Making Methods A Comparative Study
- 10. Overcoming Reading Challenges
 - Dealing with Digital Eye Strain
 - Minimizing Distractions
 - Managing Screen Time
- 11. Cultivating a Reading Routine Multi Criteria Decision Making Methods A Comparative Study
 - Setting Reading Goals Multi Criteria Decision Making Methods A Comparative Study
 - Carving Out Dedicated Reading Time
- 12. Sourcing Reliable Information of Multi Criteria Decision Making Methods A Comparative Study
 - Fact-Checking eBook Content of Multi Criteria Decision Making Methods A Comparative Study
 - 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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