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Uncertainty Modeling for Engineering Applications CRC Press
This book presents a philosophical approach to probability and probabilistic thinking, considering the underpinnings of probabilistic reasoning and modeling, which effectively underlie everything in data science. The ultimate goal is to call into question many standard tenets and lay the philosophical and probabilistic groundwork and infrastructure for statistical modeling. It is the first book devoted to the philosophy of data aimed at working scientists and calls for a new consideration in the practice of probability and statistics to eliminate what has been referred to as the "Cult of Statistical Significance." The book explains the philosophy of these ideas and not the mathematics, though there are a handful of mathematical examples. The topics are logically laid out, starting with basic philosophy as related to probability, statistics, and science, and stepping through the key probabilistic ideas and concepts, and ending with statistical models. Its jargon-free approach asserts that standard methods, such as out-of-the-box regression, cannot help in discovering cause. This new way of looking at uncertainty ties together disparate fields — probability, physics, biology, the “ soft ” sciences, computer science — because each aims at discovering cause (of effects). It broadens the understanding beyond frequentist and Bayesian methods to propose a Third Way of modeling.
Uncertainty in Biology John Wiley & Sons
Uncertainty has been of concern to engineers, managers and . scientists for many centuries. In management sciences there have existed definitions of uncertainty in a rather narrow sense since the beginning of this century. In engineering and uncertainty has for a long time been considered as in sciences, however, synonymous with random, stochastic, statistic, or probabilistic. Only since the early sixties views on uncertainty have ~ecome more heterogeneous and more tools to model uncertainty than statistics have been proposed by several scientists. The problem of modeling uncertainty adequately has become more important the more complex systems have become, the faster the scientific and engineering world develops, and the more important, but also more difficult, forecasting of future states of systems have become. The first question one should probably ask is whether uncertainty is a phenomenon, a feature of real world systems, a state of mind or a label for a situation in which a human being wants to make statements about phenomena, i. e. , reality, models, and theories, respectively. One cart also ask whether uncertainty is an objective fact or just a subjective impression which is closely related to individual persons. Whether uncertainty is an objective feature of physical real systems seems to be a philosophical question. This shall not be answered in this volume.
Uncertainty Theory Springer
"Mathematics of Uncertainty" provides the basic ideas and foundations of uncertainty, covering the fields of mathematics in which uncertainty, variability, imprecision and fuzziness of data are of importance. This introductory book describes the basic ideas of the mathematical fields of uncertainty from simple interpolation to wavelets, from error propagation to fuzzy sets and neural networks. The book presents the treatment of problems of interpolation and approximation, as well as observation fuzziness which can essentially influence the preciseness and reliability of statements on functional relationships. The notions of randomness and probability are examined as a model for the variability of observation and measurement results. Besides these basic ideas the book also presents methods of qualitative data analysis such as cluster analysis and classification, and of evaluation of functional relationships such as regression analysis and quantitative fuzzy data analysis.
Coping with Uncertainty CRC Press
This book features 29 peer-reviewed papers presented at the 9th International Conference on Soft Methods in Probability and Statistics (SMPS 2018), which was held in conjunction with the 5th International Conference on Belief Functions (BELIEF 2018) in Compiègne, France on September 17–21, 2018. It includes foundational, methodological and applied contributions on topics as varied as imprecise data handling, linguistic summaries, model coherence, imprecise Markov chains, and robust optimisation. These proceedings were produced using EasyChair. Over recent decades, interest in extensions and alternatives to probability and statistics has increased significantly in diverse areas, including decision-making, data mining and machine learning, and optimisation. This interest stems from the need to enrich existing models, in order to include different facets of uncertainty, like ignorance, vagueness, randomness, conflict or imprecision. Frameworks such as rough sets, fuzzy sets, fuzzy random variables, random sets, belief functions, possibility theory, imprecise probabilities, lower previsions, and desirable gambles all share this goal, but have emerged from different needs. The advances, results and tools presented in this book are important in the ubiquitous and fast-growing fields of data science, machine learning and artificial intelligence. Indeed, an important aspect of some of the learned predictive models is the trust placed in them. Modelling the uncertainty associated with the data and the models carefully and with principled methods is one of the means of increasing this trust, as the model will then be able to distinguish between reliable and less reliable predictions. In addition, extensions such as fuzzy sets can be explicitly designed to provide interpretable predictive models, facilitating user interaction and increasing trust.
Data Uncertainty and Important Measures Springer
Recognition of the need to introduce the ideas of uncertainty in a wide variety of scientific fields today reflects in part some of the profound changes in science and engineering over the last decades. Nobody questions the ever-present need for a solid foundation in applied mechanics. Neither does anyone question nowadays the fundamental necessity to recognize that uncertainty exists, to learn to evaluate it rationally, and to incorporate it into design. This volume provides a timely and stimulating overview of the analysis of uncertainty in applied mechanics. It is not just one more rendition of the traditional treatment of the subject, nor is it intended to supplement existing structural engineering books. Its aim is to fill a gap in the existing professional literature by concentrating on the non-probabilistic model of uncertainty. It provides an alternative avenue for the analysis of uncertainty when only a limited amount of information is available. The first chapter briefly reviews probabilistic methods and discusses the sensitivity of the probability of failure to uncertain knowledge of the system. Chapter two discusses the mathematical background of convex modelling. In the remainder of the book, convex modelling is applied to various linear and nonlinear problems. Uncertain phenomena are represented throughout the book by convex sets, and this approach is referred to as convex modelling. This book is intended to inspire researchers in their goal towards further growth and development in this field.
Modeling Change and Uncertainty Elsevier
Modelling has permeated virtually all areas of industrial, environmental, economic, bio-medical or civil engineering: yet the use of models for decision-making raises a number of issues to which this book is dedicated: How uncertain is my model ? Is it truly valuable to support decision-making ? What kind of decision can be truly supported and how can I handle residual uncertainty ? How much refined should the mathematical description be, given the true data limitations ? Could the uncertainty be reduced through more data, increased modeling investment or computational budget ? Should it be reduced now or later ? How robust is the analysis or the computational methods involved ? Should / could those methods be more robust ? Does it make sense to handle uncertainty, risk, lack of knowledge, variability or errors altogether ? How reasonable is the choice of probabilistic modeling for rare events ? How rare are the events to be considered ? How far does it make sense to handle extreme events and elaborate confidence figures ? Can I take advantage of expert / phenomenological knowledge to tighten the probabilistic figures ? Are there connex domains that could provide models or inspiration for my problem ? Written by a leader at the crossroads of industry, academia and engineering, and based on decades of multi-disciplinary field experience, Modelling Under Risk and Uncertainty gives a self-consistent introduction to the methods involved by any type of modeling development acknowledging the inevitable uncertainty and associated risks. It goes beyond the “black-box” view that some analysts, modelers, risk experts or statisticians develop on the underlying phenomenology of the environmental or industrial processes, without valuing enough their physical properties and inner modelling potential nor challenging the practical plausibility of mathematical hypotheses; conversely it is also to attract environmental or engineering modellers to better handle model confidence issues through finer statistical and risk analysis material taking advantage of advanced scientific computing, to face new regulations departing from deterministic design or support robust decision-making. Modelling Under Risk and Uncertainty: Addresses a concern of growing interest for large industries, environmentalists or analysts: robust modeling for decision-making in complex systems. Gives new insights into the peculiar mathematical and computational challenges generated by recent industrial safety or environmental control analysis for rare events. Implements decision theory choices differentiating or aggregating the dimensions of risk/aleatory and epistemic uncertainty through a consistent multi-disciplinary set of statistical estimation, physical modelling, robust computation and risk analysis. Provides an original review of the advanced inverse probabilistic approaches for model identification, calibration or data assimilation, key to digest fast-growing multi-physical data acquisition. Illustrated with one favourite pedagogical example crossing natural risk, engineering and economics, developed throughout the book to facilitate the reading and understanding. Supports Master/PhD-level course as well as advanced tutorials for professional training Analysts and researchers in numerical modeling, applied statistics, scientific computing, reliability, advanced engineering, natural risk or environmental science will benefit from this book.
Applied Research in Uncertainty Modeling and Analysis Springer Science & Business Media
"Mathematical modeling is a powerful craft that requires practice. The more practice the better one will become in executing the art. The authors wrote this book to develop the craft of mathematical modeling and to foster a desire for lifelong learning, habits of mind and develop competent and confident problem solvers and decision makers for the 21st century. This book offers a problem-solving approach. The authors introduce a problem to help motivate the learning of a particular mathematical modeling topic. The problem provides the issue or what is needed to solve using an appropriate modeling technique. Then principles are applied to the problem and present the steps in obtaining an appropriate model to solve the problem. Modeling Change and Uncertainty: Covers both linear and nonlinear models of discrete dynamical systems. Introduces statistics and probability modeling Introduces critical statistical concepts to handle univariate and multivariate data. stablishes a foundation in probability modeling. Uses ordinary

differential equations (ODEs) to develop a more robust solution to problems. Uses linear programming and machine learning to support decision making. Introduces the reality of uncertainty and randomness that is all around us Discusses the use of linear programing to solve common problems in modern industry. Discusses he power and limitations of simulations Introduces the methods and formulas used in businesses and financial organizations. Introduces valuable techniques using Excel, MAPLE, and R. Mathematical modeling offers a framework for decision makers in all fields. This framework consists of four key components: the formulation process, the solution process, interpretation of the solution in the context of the actual problem, and sensitivity analysis"--

Uncertainty Modeling and Analysis in Engineering and the Sciences John Wiley & Sons

"This book provides the reader with basic concepts for soft computing and other methods for various means of uncertainty in handling solutions, analysis, and applications"--

Modeling Change and Uncertainty Springer Science & Business Media

Modeling and Inverse Problems in the Presence of Uncertainty collects recent research—including the authors' own substantial projects—on uncertainty propagation and quantification. It covers two sources of uncertainty: where uncertainty is present primarily due to measurement errors and where uncertainty is present due to the modeling formulation itself. After a useful review of relevant probability and statistical concepts, the book summarizes mathematical and statistical aspects of inverse problem methodology, including ordinary, weighted, and generalized least-squares formulations. It then discusses asymptotic theories, bootstrapping, and issues related to the evaluation of correctness of assumed form of statistical models. The authors go on to present methods for evaluating and comparing the validity of appropriateness of a collection of models for describing a given data set, including statistically based model selection and comparison techniques. They also explore recent results on the estimation of probability distributions when they are embedded in complex mathematical models and only aggregate (not individual) data are available. In addition, they briefly discuss the optimal design of experiments in support of inverse problems for given models. The book concludes with a focus on uncertainty in model formulation itself, covering the general relationship of differential equations driven by white noise and the ones driven by colored noise in terms of their resulting probability density functions. It also deals with questions related to the appropriateness of discrete versus continuum models in transitions from small to large numbers of individuals. With many examples throughout addressing problems in physics, biology, and other areas, this book is intended for applied mathematicians interested in deterministic and/or stochastic models and their interactions. It is also suitable for scientists in biology, medicine, engineering, and physics working on basic modeling and inverse problems, uncertainty in modeling, propagation of uncertainty, and statistical modeling.

Coping with Uncertainty Chapman & Hall

When compared to classical sciences such as math, with roots in prehistory, and physics, with roots in antiquity, geographical information science (GISci) is the new kid on the block. Its theoretical foundations are therefore still developing and data quality and uncertainty modeling for spatial data and spatial analysis is an important branch of t

Linear Models in the Mathematics of Uncertainty C&h/CRC Press

Mathematics of Uncertainty Modeling in the Analysis of Engineering and Science ProblemsIGI Global

Modelling Under Risk and Uncertainty IGI Global

The first part of the book defines the concept of uncertainties and the mathematical frameworks that will be used for uncertainty modeling. The application to system reliability assessment illustrates the concept. In the second part, evidential networks as a new tool to model uncertainty in reliability and risk analysis is proposed and described. Then it is applied on SIS performance assessment and in risk analysis of a heat sink. In the third part, Bayesian and evidential networks are used to deal with important measures evaluation in the context of uncertainties.

Uncertainty Quantification Springer

The field of uncertainty quantification is evolving rapidly because of increasing emphasis on models that require quantified uncertainties for large-scale applications, novel algorithm development, and new computational architectures that facilitate implementation of these algorithms. Uncertainty Quantification: Theory, Implementation, and Applications provides readers with the basic concepts, theory, and algorithms necessary to quantify input and response uncertainties for simulation models arising in a broad range of disciplines. The book begins with a detailed discussion of applications where uncertainty quantification is critical for both scientific understanding and policy. It then covers concepts from probability and statistics, parameter selection techniques, frequentist and Bayesian model calibration, propagation of uncertainties, quantification of model discrepancy, surrogate model construction, and local and global sensitivity analysis. The author maintains a complementary web page where readers can find data used in the exercises and other supplementary material.

Principles of Modeling Uncertainties in Spatial Data and Spatial Analyses Springer Science & Business Media

Ongoing global changes pose fundamentally new scientific problems requiring new concepts and tools. A key issue concerns a vast variety of practically irreducible uncertainties, which challenge traditional models and require new concepts and analytical tools. Uncertainty can dominate, as in the climate change debates. Increasing the resolution of models does not always yield sufficient certainty. This book presents much-needed new tools for modeling and management of uncertainty.

Uncertain Input Data Problems and the Worst Scenario Method Springer Science & Business Media

Mathematical modeling is a powerful craft that requires practice. The more practice the better one will become in executing the art. The authors wrote this book to develop the craft of mathematical modeling and to foster a desire for lifelong learning, habits of mind and develop competent and confident problem solvers and decision makers for the 21st century. This book offers a problem-solving approach. The authors introduce a problem to help motivate the learning of a particular mathematical modeling topic. The problem provides the issue or what is needed to solve using an appropriate modeling technique. Then principles are applied to the problem and present the steps in obtaining an appropriate model to solve the problem. Modeling Change and Uncertainty: Covers both linear and nonlinear models of discrete dynamical systems. Introduces statistics and probability modeling. Introduces critical statistical concepts to handle univariate and multivariate data. Establishes a foundation in probability modeling. Uses ordinary differential equations (ODEs) to develop a more robust solution to problems. Uses linear programming and machine learning to support decision making. Introduces the reality of uncertainty and randomness that is all around us. Discusses the use of linear programing to solve common problems in modern industry. Discusses he power and limitations of simulations. Introduces the methods and formulas used in businesses and financial organizations. Introduces valuable techniques using Excel, MAPLE, and R. Mathematical modeling offers a framework for decision makers in all fields. This framework consists of four key components: the formulation process, the solution process, interpretation of the solution in the context of the actual problem, and sensitivity analysis. Modeling Change and Uncertainty will be of interest to mathematics departments offering advanced mathematical modeling courses focused on decision making or discrete mathematical modeling and by undergraduate, graduate students and practitioners looking for an opportunity to develop, practice, and apply the craft of mathematical modeling. Table of Contents 1. Perfect Partners: Combining Models of Change and Uncertainty with Technology 2. Modeling Change: Discrete Dynamical Systems (DDS) and Modeling Systems of DDS 3. Statistical and Probabilistic Models 4. Modeling with Probability 5. Differential Equations 6. Forecasting with Linear Programming and Machine Learning 7. Stochastic Models and Markov Chains 8. Linear Programming 9. Simulation of Queueing Models 10. Modeling of Financial Analysis 11. Reliability Models 12. Machine Learning and Unconstrained Optimal Process Dr. William P. Fox is currently a visiting professor of Computational Operations Research at the College of William and Mary. He is an emeritus professor in the Department of Defense Analysis at the Naval Postgraduate School and teaches a three-course sequence in mathematical modeling for decision making. He received his Ph.D. in Industrial Engineering from Clemson University. He has taught at the United States Military Academy for twelve years until retiring and at Francis Marion University where he was the chair of mathematics for eight years. He has many publications and scholarly activities including twenty plus books and one hundred and fifty journal articles. Colonel (R) Robert E. Burks, Jr., Ph.D. is an Associate Professor in the Defense Analysis Department of the Naval Postgraduate School (NPS) and the Director of the NPS' Wargaming Center. He holds a Ph.D. in Operations Research from the Air Force Institute of Technology. He is a retired logistics Army Colonel with more than thirty years of military experience in leadership, advanced analytics, decision modeling, and logistics operations who served as an Army Operations Research analyst at the Naval Postgraduate School, TRADOC Analysis Center, United States Military Academy, and the United States Army Recruiting Command. Other book by William P. Fox and Robert E. Burks: Advanced Mathematical Modeling with Technology, 2021, CRC Press. Other books by William P. Fox from CRC Press: Mathematical Modeling in the Age of the Pandemic, 2021, CRC Press. Advanced Problem Solving Using Maple: Applied Mathematics, Operations Research, Business Analytics, and Decision Analysis (w/William Bauldry), 2020, CRC Press. Mathematical Modeling with Excel (w/Brian Albright), 2020, CRC Press. Nonlinear Optimization: Models and Applications, 2020, CRC Press. Advanced Problem Solving with Maple: A First Course (w/William Bauldry), 2019. CRC Press. Mathematical Modeling for Business Analytics, 2018, CRC Press.

Do Dice Play God? CRC Press

The application areas of uncertainty are numerous and diverse, including all fields of engineering, computer science, systems control and finance. Determining appropriate ways and methods of dealing with uncertainty has been a constant challenge. The theme for this book is better understanding and the application of uncertainty theories. This book, with invited chapters, deals with the uncertainty phenomena in diverse fields. The book is an outgrowth of the Fourth International Symposium on Uncertainty Modeling and Analysis (ISUMA), which was held at the center of Adult Education, College Park, Maryland, in September 2003. All of the chapters have been carefully edited, following a review process in which the editorial committee scrutinized each chapter. The contents of the book are reported in twenty-three chapters, covering more than . . ... pages. This book is divided into six main sections. Part I (Chapters 1-4) presents the philosophical and theoretical foundation of uncertainty, new computational directions in neural networks, and some theoretical foundation of fuzzy systems. Part I1 (Chapters 5-8) reports on biomedical and chemical engineering applications. The sections looks at noise reduction techniques using hidden Markov models, evaluation of biomedical signals using neural networks, and changes in medical image detection using Markov Random Field and Mean Field theory. One of the chapters reports on optimization in chemical engineering processes.

Dynamics under Uncertainty John Wiley & Sons

The world we live in is pervaded with uncertainty and imprecision. Is it likely to rain this afternoon? Should I take an umbrella with me? Will I be able to find parking near the campus? Should I go by bus? Such simple questions are a c- mon occurrence in our daily lives. Less simple examples: What is the probability that the price of oil will rise sharply in the near future? Should I buy Chevron stock? What are the chances that a bailout of GM, Ford and Chrysler will not s- ceed? What will be the consequences? Note that the examples in question involve both uncertainty and imprecision. In the real world, this is the norm rather than exception. There is a deep-seated tradition in science of employing probability theory, and only probability theory, to deal with uncertainty and imprecision. The mon- oly of probability theory came to an end when fuzzy logic made its debut. H- ever, this is by no means a widely accepted view. The belief persists, especially within the probability community, that probability theory is all that is needed to deal with uncertainty. To quote a prominent Bayesian, Professor Dennis Lindley, "The only satisfactory description of uncertainty is probability.

Mathematics of Uncertainty Modeling in the Analysis of Engineering and Science Problems Springer

Ongoing global changes pose fundamentally new scientific problems requiring new concepts and tools. A key issue concerns a vast variety of practically irreducible uncertainties, which challenge traditional models and require new concepts and analytical tools. Uncertainty can dominate, as in the climate change debates. Increasing the resolution of models does not always yield sufficient certainty. This book presents much-needed new tools for modeling and management of uncertainty.

Modeling Uncertainty Elsevier

Cancer deaths per capita have decreased in recent years, but the improvement is attributed to prevention, not treatment. The difficulty in treating cancer may be due to its 'complexity', in the mathematical physics sense of the word. Tumors evolve and spread in response to internal and external factors that involve feedback mechanisms and nonlinear behavior. Investigations of the nonlinear interactions among cells, and between cells and their environment, are crucial for developing a sufficiently detailed understanding of the system's emergent phenomenology to be able to control the behavior. In the case of cancer, controlling the system's behavior will mean the ability to treat and cure the disease. Physicists have been studying various complex, nonlinear systems for many years using a variety of techniques. These investigations have provided insights that allow physicists to make unique contributions towards the treatment of cancer.This interdisciplinary book presents recent advancements in physicists' research on cancer. The work presented in this volume uses a variety of physical, biochemical, mathematical, theoretical, and computational techniques to gain a deeper molecular and cellular understanding of the horrific disease that is cancer.

Uncertainty Modeling for Structural Control Analysis and Synthesis SIAM

Uncertainty theory is a branch of mathematics based on normality, monotonicity, self-duality, countable subadditivity, and product measure axioms. Uncertainty is any concept that satisfies the axioms of uncertainty theory. Thus uncertainty is neither randomness nor fuzziness. It is also known from some surveys that a lot of phenomena do behave like uncertainty. How do we model uncertainty? How do we use uncertainty theory? In order to answer these questions, this book provides a self-contained, comprehensive and up-to-date presentation of uncertainty theory, including uncertain programming, uncertain risk analysis, uncertain reliability analysis, uncertain process, uncertain calculus, uncertain differential equation, uncertain logic, uncertain entailment, and uncertain inference. Mathematicians, researchers, engineers, designers, and students in the field of mathematics, information science, operations research, system science, industrial engineering, computer science, artificial intelligence, finance, control, and management science will find this work a stimulating and useful reference.