Modeling And Reasoning With Bayesian Networks

This book constitutes the proceedings of the 10th International Workshop on Fuzzy Logic and Applications, WILF 2013, held in Genoa, Italy, in November 2013. After a rigorous peer-review selection process, ultimately 19 regular papers were selected for inclusion in this volume from 29 submissions. In addition the book contains 3 keynote talks and 2 tutorials. The papers are organized in topical sections named: fuzzy machine learning and interpretability; theory and applications.

The increasing complexity of our world demands new perspectives on the role of technology in decision making. Human decision making has its li- tations in terms of information-processing capacity. We need new technology to cope with the increasingly complex and information-rich nature of our modern society. This is particularly true for critical environments such as crisis management and tra?c management, where humans need to engage in close collaborations with arti?cial systems to observe and understand the situation and respond in a sensible way. We believe that close collaborations between humans and arti?cial systems will become essential and that the importance of research into Interactive Collaborative Information Systems (ICIS) is self-evident. Developments in information and communication technology have ra- cally changed our working environments. The vast amount of information available nowadays and the wirelessly networked nature of our modern so- ety open up new opportunities to handle di?cult decision-making situations such as computer-supported situation assessment and distributed decision making. To make good use of these new possibilities, we need to update our traditional views on the role and capabilities of information systems. The aim of the Interactive Collaborative Information Systems project is to develop techniques that support humans in complex information en- ronments and that facilitate distributed decision-making capabilities. ICIS emphasizes the importance of building actor-agent communities: close c- laborations between human and arti?cial actors that highlight their comp- mentary capabilities, and in which task distribution is ?exible and adaptive.

This book provides a thorough introduction to the formal foundations and practical applications of Bayesian networks. It provides an extensive discussion of techniques for building Bayesian networks that model real-world situations, including techniques for synthesizing models from design, learning models from data, and debugging models using sensitivity analysis. It also treats exact and approximate inference algorithms at both theoretical and practical levels. The author assumes very little background on the covered subjects, supplying in-depth discussions for theoretically inclined readers and enough practical details to provide an algorithmic cookbook for the system developer.

This book serves as a textbook or reference for anyone with an interest in probabilistic modeling in the fields of computer science, computer engineering, and electrical engineering. This text is also a resource for courses on expert systems, machine learning, and artificial intelligence. Beginning with a basic theoretical introduction, the author then provides a discussion of inference, methods of learning, and applications based on Bayesian networks and beyond.

Advanced Methodologies for Bayesian Networks

Bayesian Time Series Models

Bayesian Rationality

Principles and Applications

Recent Research Trend in Data-Driven Predictive Analytics

Modeling, Learning and Reasoning with Structured Bayesian Networks

This thesis proposes a computational framework for understanding human Theory of Mind (ToM): our conception of others' mental states, how they relate to the world, and how they cause behavior. Humans use ToM to predict others' actions, given their mental states, but also to do the reverse: attribute mental states - beliefs, desires, intentions, knowledge, goals, preferences, emotions, and other thoughts - to explain others' behavior. The goal of this thesis is to provide a formal account of the knowledge and mechanisms that support these judgments. The thesis will argue for three central claims about human ToM. First, ToM is constructed around probabilistic, causal models of how agents' beliefs, desires and goals interact with their situation and perspective (which can differ from our own) to produce behavior. Second, the core content of ToM can be formalized using context-specific models of approximately rational planning, such as Markov decision processes (MDPs), partially observable MDPs (POMDPs), and Markov games. ToM reasoning will be formalized as rational probabilistic inference over these models of intentional (inter)action, termed Bayesian Theory of Mind (BToM). Third, hypotheses about the structure and content of ToM can be tested through a combination of computational modeling and behavioral experiments. An experimental paradigm for eliciting fine-grained ToM judgments will be proposed, based on comparing human inferences about the mental states and behavior of agents moving within simple two-dimensional scenarios with the inferences predicted by computational models. Three sets of experiments will be presented, investigating models of human goal inference (Chapter 2), joint belief-desire inference (Chapter 3), and inference of interactively-defined goals, such as chasing and fleeing (Chapter 4). BToM, as well as a selection of prominent alternative proposals from the social perception literature will be evaluated by their quantitative fit to behavioral data. Across the present experiments, the high accuracy of BToM, and its performance relative to alternative models, will demonstrate the difficulty of capturing human social judgments, and the success of BToM in meeting this challenge.

Now in its third edition, this classic book is widely considered the leading text on Bayesian methods, lauded for its accessible,

practical approach to analyzing data and solving research problems. Bayesian Data Analysis, Third Edition continues to take an applied approach to analysis using up-to-date Bayesian methods. The authors—all leaders in the statistics community—introduce basic concepts from a data-analytic perspective before presenting advanced methods. Throughout the text, numerous worked examples drawn from real applications and research emphasize the use of Bayesian inference in practice. New to the Third Edition Four new chapters on nonparametric modeling Coverage of weakly informative priors and boundary-avoiding priors Updated discussion of cross-validation and predictive information criteria Improved convergence monitoring and effective sample size calculations for iterative simulation Presentations of Hamiltonian Monte Carlo, variational Bayes, and expectation propagation New and revised software code The book can be used in three different ways. For undergraduate students, it introduces Bayesian inference starting from first principles. For graduate students, the text presents effective current approaches to Bayesian modeling and computation in statistics and related fields. For researchers, it provides an assortment of Bayesian methods in applied statistics. Additional materials, including data sets used in the examples, solutions to selected exercises, and software instructions, are available on the book's web page.

The first unified treatment of time series modelling techniques spanning machine learning, statistics, engineering and computer science.

This is a brand new edition of an essential work on Bayesian networks and decision graphs. It is an introduction to probabilistic graphical models including Bayesian networks and influence diagrams. The reader is guided through the two types of frameworks with examples and exercises, which also give instruction on how to build these models. Structured in two parts, the first section focuses on probabilistic graphical models, while the second part deals with decision graphs, and in addition to the frameworks described in the previous edition, it also introduces Markov decision process and partially ordered decision problems.

Introduction to Hierarchical Bayesian Modeling for Ecological Data

The Probabilistic Approach to Human Reasoning

Reasoning, Verification and Model Inaccuracies

Reasoning With Probabilistic and Deterministic Graphical Models

Bayesian Data Analysis, Third Edition

Inferential Models

A general framework for constructing and using probabilistic models of complex systems that would enable a computer to use available information for making decisions. Most tasks require a person or an automated system to reason—to reach conclusions based on available information. The framework of probabilistic graphical models, presented in this book, provides a general approach for this task. The approach is model-based, allowing interpretable models to be constructed and then manipulated by reasoning algorithms. These models can also be learned automatically from data, allowing the approach to be used in cases where manually constructing a model is difficult or even impossible. Because uncertainty is an inescapable aspect of most real-world applications, the book focuses on probabilistic models, which make the uncertainty explicit and provide models that are more faithful to reality. Probabilistic Graphical Models discusses a variety of models, spanning Bayesian networks, undirected Markov networks, discrete and continuous models, and extensions to deal with dynamical systems and relational data. For each class of models, the text describes the three fundamental cornerstones: representation, inference, and learning, presenting both basic concepts and advanced techniques. Finally, the book considers the use of the proposed framework for causal reasoning and decision making under uncertainty. The main text in each chapter provides the detailed technical development of the key ideas. Most chapters also include boxes with additional material: skill boxes, which describe techniques; case study boxes, which discuss empirical cases related to the approach described in the text, including applications in computer vision, robotics, natural language understanding, and computational biology; and concept boxes, which present significant concepts drawn from the material in the chapter. Instructors (and readers) can group chapters in various combinations, from core topics to more technically advanced material, to suit their particular needs.

This volume introduces a formal representation framework for modelling and reasoning, that allows us to quantify the uncertainty inherent in the use of vague descriptions to convey information between intelligent agents. This can then be applied across a range of applications areas in automated reasoning and learning. The utility of the framework is demonstrated by applying it to problems in data analysis where the aim is to infer effective and informative models expressed as logical rules and relations involving vague concept descriptions. The author also introduces a number of learning algorithms within the framework that can be used for both classification and prediction (regression) problems. It is shown how models of this kind can be fused with qualitative background knowledge such as that provided by domain experts. The proposed algorithms will be compared with existing learning methods on a range of benchmark databases such as those from the UCI repository.

Since the first edition of this book published, Bayesian networks have become even more important for applications in a vast array of fields. This second edition includes new material on influence diagrams, learning from data, value of information, cybersecurity, debunking bad statistics, and much more. Focusing on practical real-world problem-solving and model building, as opposed to algorithms and theory, it explains how to incorporate knowledge with data to develop and use (Bayesian) causal models of risk that provide more powerful insights and better decision making than is possible from purely data-driven solutions. Features Provides all tools necessary to build and run realistic Bayesian network models Supplies extensive example models based on real risk assessment problems in a wide range of application domains provided; for example, finance, safety, systems reliability, law, forensics, cybersecurity and more Introduces all necessary mathematics, probability, and statistics as needed Establishes the basics of

probability, risk, and building and using Bayesian network models, before going into the detailed applications A dedicated website contains exercises and worked solutions for all chapters along with numerous other resources. The AgenaRisk software contains a model library with executable versions of all of the models in the book. Lecture slides are freely available to accredited academic teachers adopting the book on their course.

Formal ways of representing uncertainty and various logics for reasoning about it; updated with new material on weighted probability measures, complexity-theoretic considerations, and other topics. In order to deal with uncertainty intelligently, we need to be able to represent it and reason about it. In this book, Joseph Halpern examines formal ways of representing uncertainty and considers various logics for reasoning about it. While the ideas presented are formalized in terms of definitions and theorems, the emphasis is on the philosophy of representing and reasoning about uncertainty. Halpern surveys possible formal systems for representing uncertainty, including probability measures, possibility measures, and plausibility measures; considers the updating of beliefs based on changing information and the relation to Bayes' theorem; and discusses qualitative, quantitative, and plausibilistic Bayesian networks. This second edition has been updated to reflect Halpern's recent research. New material includes a consideration of weighted probability measures and how they can be used in decision making; analyses of the Doomsday argument and the Sleeping Beauty problem; modeling games with imperfect recall using the runs-and-systems approach; a discussion of complexity-theoretic considerations; the application of first-order conditional logic to security. Reasoning about Uncertainty is accessible and relevant to researchers and students in many fields, including computer science, artificial intelligence, economics (particularly game theory), mathematics, philosophy, and statistics.

Advances in Bayesian Networks

Towards Bayesian Model-Based Demography

Probabilistic Graphical Models

Representations for Learning, Reasoning and Data Mining

Bayesian Networks

A Practical Introduction for Researchers

This handbook presents some of the most recent topics in neural information processing, covering both theoretical concepts and practical applications. The contributions include: Deep architectures Recurrent, recursive, and graph neural networks Cellular neural networks Bayesian networks Approximation capabilities of neural networks Semi-supervised learning Statistical relational learning Kernel methods for structured data Multiple classifier systems Self organisation and modal learning Applications to content-based image retrieval, text mining in large document collections, and bioinformatics This book is thought particularly for graduate students, researchers and practitioners, willing to deepen their knowledge on more advanced connectionist models and related learning paradigms.

Bayesian Networks: With Examples in R, Second Edition introduces Bayesian networks using a hands-on approach. Simple yet meaningful examples illustrate each step of the modelling process and discuss side by side the underlying theory and its application using R code. The examples start from the simplest notions and gradually increase in complexity. In particular, this new edition contains significant new material on topics from modern machine-learning practice: dynamic networks, networks with heterogeneous variables, and model validation. The first three chapters explain the whole process of Bayesian network modelling, from structure learning to parameter learning to inference. These chapters cover discrete, Gaussian, and conditional Gaussian Bayesian networks. The following two chapters delve into dynamic networks (to model temporal data) and into networks including arbitrary random variables (using Stan). The book then gives a concise but rigorous treatment of the fundamentals of Bayesian networks and offers an introduction to causal Bayesian networks. It also presents an overview of R packages and other software implementing Bayesian networks. The final chapter evaluates two real-world examples: a landmark causal protein-signalling network published in Science and a probabilistic graphical model for predicting the composition of different body parts. Covering theoretical and practical aspects of Bayesian networks, this book provides you with an introductory overview of the field. It gives you a clear, practical understanding of the key points behind this modelling approach and, at the same time, it makes you familiar with the most relevant packages used to implement real-world analyses in R. The examples covered in the book span several application fields, data-driven models and expert systems, probabilistic and causal perspectives, thus giving you a starting point to work in a variety of scenarios. Online supplementary materials include the data sets and the code used in the book, which will all be made available from https://www.bnlearn.com/book-crc-2ed/

Master Bayesian Inference through Practical Examples and Computation–Without Advanced Mathematical Analysis Bayesian methods of inference are deeply natural and extremely powerful. However, most discussions of Bayesian inference rely on intensely complex mathematical analyses and artificial examples, making it inaccessible to anyone without a strong mathematical background. Now, though, Cameron Davidson-Pilon introduces Bayesian inference from a computational perspective, bridging theory to practice–freeing you to get results using computing power. Bayesian Methods for Hackers illuminates Bayesian inference through probabilistic programming with the powerful PyMC language and the closely related Python tools NumPy, SciPy, and Matplotlib. Using this approach, you can reach effective solutions in small increments, without extensive mathematical intervention. Davidson-Pilon begins by introducing the concepts underlying Bayesian inference, comparing it with other techniques and guiding you through building and training your first Bayesian model. Next, he introduces PyMC through a series of detailed examples and intuitive explanations that have been refined after extensive user

feedback. You'll learn how to use the Markov Chain Monte Carlo algorithm, choose appropriate sample sizes and priors, work with loss functions, and apply Bayesian inference in domains ranging from finance to marketing. Once you've mastered these techniques, you'll constantly turn to this guide for the working PyMC code you need to jumpstart future projects. Coverage includes • Learning the Bayesian "state of mind" and its practical implications • Understanding how computers perform Bayesian inference • Using the PyMC Python library to program Bayesian analyses • Building and debugging models with PyMC • Testing your model's "goodness of fit" • Opening the "black box" of the Markov Chain Monte Carlo algorithm to see how and why it works • Leveraging the power of the "Law of Large Numbers" • Mastering key concepts, such as clustering, convergence, autocorrelation, and thinning • Using loss functions to measure an estimate's weaknesses based on your goals and desired outcomes • Selecting appropriate priors and understanding how their influence changes with dataset size • Overcoming the "exploration versus exploitation" dilemma: deciding when "pretty good" is good enough • Using Bayesian inference to improve A/B testing • Solving data science problems when only small amounts of data are available Cameron Davidson-Pilon has worked in many areas of applied mathematics, from the evolutionary dynamics of genes and diseases to stochastic modeling of financial prices. His contributions to the open source community include lifelines, an implementation of survival analysis in Python. Educated at the University of Waterloo and at the Independent University of Moscow, he currently works with the online commerce leader Shopify.

PIONEERING WORK SHOWS HOW USING DIAGRAMS FACILITATES THE DESIGN OF BETTER AI SYSTEMS The publication of Diagrammatic Reasoning in AI marks an important milestone for anyone seeking to design graphical user interfaces to support decision-making and problem-solving tasks. The author expertly demonstrates how diagrammatic representations can simplify our interaction with increasingly complex information technologies and computer-based information systems. In particular, the book emphasizes how diagrammatic user interfaces can help us better understand and visualize artificial intelligence (AI) systems. It examines how diagrammatic reasoning enhances various AI programming strategies used to emulate human thinking and problem-solving, including: Expert systems Model-based reasoning Inexact reasoning such as certainty factors and Bayesian networks Logic reasoning A key part of the book is its extensive development of applications and graphical illustrations, drawing on such fields as the physical sciences, macroeconomics, finance, business logistics management, and medicine. Despite such tremendous diversity of usage, in terms of applications and diagramming notations, the book classifies and organizes diagrams around six major themes: system topology; sequence and flow; hierarchy and classification; association; cause and effect; and logic reasoning. Readers will benefit from the author's discussion of how diagrams can be more than just a static picture or representation and how diagrams can be a central part of an intelligent user interface, meant to be manipulated and modified, and in some cases, utilized to infer solutions to difficult problems. This book is ideal for many different types of readers: practitioners and researchers in AI and human-computer interaction; business and computing professionals; graphic designers and designers of graphical user interfaces; and just about anyone interested in understanding the power of diagrams. By discovering the many different types of diagrams and their applications in AI, all readers will gain a deeper appreciation of diagrammatic reasoning.

Probability and Bayesian Modeling

Modeling Human Reasoning about Beliefs, Desires, Goals, and Social Relations

Interactive Collaborative Information Systems

Probabilistic Reasoning in Multiagent Systems

With Examples in R

Quantified Representation of Uncertainty and Imprecision

A New Approach to Sound Statistical ReasoningInferential Models: Reasoning with Uncertainty introduces the authors' recently developed approach to inference: the inferential model (IM) framework. This logical framework for exact probabilistic inference does not require the user to input prior information. The authors show how an IM produces meaning

Graphical models are of increasing importance in applied statistics, and in particular in data mining. Providing a self-contained introduction and overview to learning relational, probabilistic, and possibilistic networks from data, this second edition of Graphical Models is thoroughly updated to include the latest research in this burgeoning field, including a new chapter on visualization. The text provides graduate students, and researchers with all the necessary background material, including modelling under uncertainty, decomposition of distributions, graphical representation of distributions, and applications relating to graphical models and problems for further research.

For almost 2,500 years, the Western concept of what is to be human has been dominated by the idea that the mind is the seat of reason - humans are, almost by definition, the rational animal. In this text a more radical suggestion for explaining these puzzling aspects of human reasoning is put forward.

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.

Diagrammatic Reasoning in AI

Bayesian Networks and BayesiaLab

Enhanced Bayesian Network Models for Spatial Time Series Prediction

The Soul of Modeling, Probability & Statistics

Learning Bayesian Networks

Modeling and Reasoning with Bayesian Networks

Graphical models (e.g., Bayesian and constraint networks, influence diagrams, and Markov decision processes) have become a central paradigm for knowledge representation and reasoning in both artificial intelligence and computer science in general. These models are used to perform many reasoning tasks, such as scheduling, planning and learning, diagnosis and prediction, design, hardware and software verification, and bioinformatics. These problems can be stated as the formal tasks of constraint satisfaction and satisfiability, combinatorial optimization, and probabilistic inference. It is well known that the tasks are computationally hard, but research during the past three decades has yielded a variety of principles and techniques that significantly advanced the state of the art. This book provides comprehensive coverage of the primary exact algorithms for reasoning with such models. The main feature exploited by the algorithms is the model's graph. We present inference-based, message-passing schemes (e.g., variable-elimination) and search-based, conditioning schemes (e.g., cycle-cutset conditioning and AND/OR search). Each class possesses distinguished characteristics and in particular has different time vs. space behavior. We emphasize the dependence of both schemes on few graph parameters such as the treewidth, cycle-cutset, and (the pseudo-tree) height. The new edition includes the notion of influence diagrams, which focus on sequential decision making under uncertainty. We believe the principles outlined in the book would serve well in moving forward to approximation and anytime-based schemes. The target audience of this book is researchers and students in the artificial intelligence and machine learning area, and beyond.

In recent years probabilistic graphical models, especially Bayesian networks and decision graphs, have experienced significant theoretical development within areas such as artificial intelligence and statistics. This carefully edited monograph is a compendium of the most recent advances in the area of probabilistic graphical models such as decision graphs, learning from data and inference. It presents a survey of the state of the art of specific topics of recent interest of Bayesian Networks, including approximate propagation, abductive inferences, decision graphs, and applications of influence. In addition, Advances in Bayesian Networks presents a careful selection of applications of probabilistic graphical models to various fields such as speech recognition, meteorology or information retrieval.

This volume constitutes the refereed proceedings of the Second International Workshop on Advanced Methodologies for Bayesian Networks, AMBN 2015, held in Yokohama, Japan, in November 2015. The 18 revised full papers and 6 invited abstracts presented were carefully reviewed and selected from numerous submissions. In the International Workshop on Advanced Methodologies for Bayesian Networks (AMBN), the researchers explore methodologies for enhancing the effectiveness of graphical models including modeling, reasoning, model selection, logic-probability relations, and causality. The exploration of methodologies is complemented discussions of practical considerations for applying graphical models in real world settings, covering concerns like scalability, incremental learning, parallelization, and so on.

This 2002 book investigates the opportunities in building intelligent decision support systems offered by multi-agent distributed probabilistic reasoning. Probabilistic reasoning with graphical models, also known as Bayesian networks or belief networks, has become increasingly an active field of research and practice in artificial intelligence, operations research and statistics. The success of this technique in modeling intelligent decision support systems under the centralized and single-agent paradigm has been striking. Yang Xiang extends graphical dependence models to the distributed and multi-agent paradigm. He identifies the major technical challenges involved in such an endeavor and presents the results. The framework developed in the book allows distributed representation of uncertain knowledge on a large and complex environment embedded in multiple cooperative agents, and effective, exact and distributed probabilistic inference.

Exact Algorithms

Bayesian Psychometric Modeling

Modelling and Reasoning with Vague Concepts

Bayesian Reasoning and Machine Learning

Reasoning with Probabilistic and Deterministic Graphical Models

Uncertainty

We are happy to present the first volume of the Handbook of Defeasible Reasoning and Uncertainty Management Systems. Uncertainty pervades the real world and must therefore be addressed by every system that attempts to represent reality. The representation of uncertainty is a ma jor concern of philosophers, logicians, artificial intelligence researchers and com puter sciencists, psychologists, statisticians, economists and engineers. The present Handbook volumes provide frontline coverage of this area. This Handbook was produced in the style of previous handbook series like the Handbook of Philosoph ical Logic, the Handbook of Logic in Computer Science, the Handbook of Logic in Artificial Intelligence and Logic Programming, and can be seen as a companion to them in covering the wide applications of logic and reasoning. We hope it will answer the needs for adequate representations of uncertainty. This Handbook series grew out of the ESPRIT Basic Research Project DRUMS II, where the acronym is made out of the Handbook series title. This project was financially supported by the European Union and regroups 20 major European research teams

working in the general domain of uncertainty. As a fringe benefit of the DRUMS project, the research community was able to create this Hand book series, relying on the DRUMS participants as the core of the authors for the Handbook together with external international experts.

This research monograph is highly contextual in the present era of spatial/spatio-temporal data explosion. The overall text contains many interesting results that are worth applying in practice, while it is also a source of intriguing and motivating questions for advanced research on spatial data science. The monograph is primarily prepared for graduate students of Computer Science, who wish to employ probabilistic graphical models, especially Bayesian networks (BNs), for applied research on spatial/spatio-temporal data. Students of any other discipline of engineering, science, and technology, will also find this monograph useful. Research students looking for a suitable problem for their MS or PhD thesis will also find this monograph beneficial. The open research problems as discussed with sufficient references in Chapter-8 and Chapter-9 can immensely help graduate researchers to identify topics of their own choice. The various illustrations and proofs presented throughout the monograph may help them to better understand the working principles of the models. The present monograph, containing sufficient description of the parameter learning and inference generation process for each enhanced BN model, can also serve as an algorithmic cookbook for the relevant system developers.

Probability and Bayesian Modeling is an introduction to probability and Bayesian thinking for undergraduate students with a calculus background. The first part of the book provides a broad view of probability including foundations, conditional probability, discrete and continuous distributions, and joint distributions. Statistical inference is presented completely from a Bayesian perspective. The text introduces inference and prediction for a single proportion and a single mean from Normal sampling. After fundamentals of Markov Chain Monte Carlo algorithms are introduced, Bayesian inference is described for hierarchical and regression models including logistic regression. The book presents several case studies motivated by some historical Bayesian studies and the authors' research. This text reflects modern Bayesian statistical practice. Simulation is introduced in all the probability chapters and extensively used in the Bayesian material to simulate from the posterior and predictive distributions. One chapter describes the basic tenets of Metropolis and Gibbs sampling algorithms; however several chapters introduce the fundamentals of Bayesian inference for conjugate priors to deepen understanding. Strategies for constructing prior distributions are described in situations when one has substantial prior information and for cases where one has weak prior knowledge. One chapter introduces hierarchical Bayesian modeling as a practical way of combining data from different groups. There is an extensive discussion of Bayesian regression models including the construction of informative priors, inference about functions of the parameters of interest, prediction, and model selection. The text uses JAGS (Just Another Gibbs Sampler) as a general-purpose computational method for simulating from posterior distributions for a variety of Bayesian models. An R package ProbBayes is available containing all of the book datasets and special functions for illustrating concepts from the book.

Causality offers the first comprehensive coverage of causal analysis in many sciences, including recent advances using graphical methods. Pearl presents a unified account of the probabilistic, manipulative, counterfactual and structural approaches to causation, and devises simple mathematical tools for analyzing the relationships between causal connections, statistical associations, actions and observations. The book will open the way for including causal analysis in the standard curriculum of statistics, artificial intelligence ...

Handbook on Neural Information Processing
Bayesian Networks and Decision Graphs
Causality
Bayesian Reasoning in Data Analysis
Graphical Models
Bayesian Methods for Hackers

A Single Cohesive Framework of Tools and Procedures for Psychometrics and Assessment Bayesian Psychometric Modeling presents a unified Bayesian approach across traditionally separate families of psychometric models. It shows that Bayesian techniques, as alternatives to conventional approaches, offer distinct and profound advantages in achieving many goals of psychometrics. Adopting a Bayesian approach can aid in unifying seemingly

disparate—and sometimes conflicting—ideas and activities in psychometrics. This book explains both how to perform psychometrics using Bayesian methods and why many of the activities in psychometrics align with Bayesian thinking. The first part of the book introduces foundational principles and statistical models, including conceptual issues, normal distribution models, Markov chain Monte Carlo estimation, and regression. Focusing more directly on psychometrics, the second part covers popular psychometric models, including classical test theory, factor analysis, item response theory, latent class analysis, and Bayesian networks. Throughout the book, procedures are illustrated using examples primarily from educational assessments. A supplementary website provides the datasets, WinBUGS code, R code, and Netica files used in the examples.

This accessible text/reference provides a general introduction to probabilistic graphical models (PGMs) from an engineering perspective. The book covers the fundamentals for each of the main classes of PGMs, including representation, inference and learning principles, and reviews real-world applications for each type of model. These applications are drawn from a broad range of disciplines, highlighting the many uses of Bayesian classifiers, hidden Markov models, Bayesian networks, dynamic and temporal Bayesian networks, Markov random fields, influence diagrams, and Markov decision processes. Features: presents a unified framework encompassing all of the main classes of PGMs; describes the practical application of the different techniques; examines the latest developments in the field, covering multidimensional Bayesian classifiers, relational graphical models and causal models; provides exercises, suggestions for further reading, and ideas for research or programming projects at the end of each chapter.

Probabilistic graphical models, e.g. Bayesian Networks, have been traditionally introduced to model and reason with uncertainty. A graph structure is crafted to capture knowledge of conditional independence relationships among random variables, which can enhance the computational complexity of reasoning. To generate such a graph, one sometimes has to provide vast and detailed knowledge about how variables interacts, which may not be readily available. In some cases, although a graph structure can be obtained from available knowledge, it can be too dense to be useful computationally. In this dissertation, we propose a new type of probabilistic graphical models called a Structured Bayesian network (SBN) that requires less detailed knowledge about conditional independences. The new model can also leverage other types of knowledge, including logical constraints and conditional independencies that are not visible in the graph structure. Using SBNs, different types of knowledge act in harmony to facilitate reasoning and learning from a stochastic world. We study SBNs across the dimensions of modeling, inference and learning. We also demonstrate some of their applications in the domain of traffic modeling.

A practical introduction perfect for final-year undergraduate and graduate students without a solid background in linear algebra and calculus.

Bayesian Theory of Mind

A Graphical Models Approach

Second International Workshop, AMBN 2015, Yokohama, Japan, November 16-18, 2015. Proceedings

10th International Workshop, WILF 2013, Genoa, Italy, November 19-22, 2013, Proceedings

Risk Assessment and Decision Analysis with Bayesian Networks

Fuzzy Logic and Applications

This book provides a multi-level introduction to Bayesian reasoning (as opposed to “conventional statistics”) and its applications to data analysis. The basic ideas of this “new” approach to the quantification of uncertainty are presented using examples from research and everyday life. Applications covered include: parametric inference; combination of results; treatment of uncertainty due to systematic errors and background; comparison of hypotheses; unfolding of experimental distributions; upper/lower bounds in frontier-type measurements. Approximate methods for routine use are derived and are shown often to coincide — under well-defined assumptions! — with “standard” methods, which can therefore be seen as special cases of the more general Bayesian methods. In dealing with uncertainty in measurements, modern metrological ideas are utilized, including the ISO classification of uncertainty into type A and type B. These are shown to fit well into the Bayesian framework. Contents: Critical Review and Outline of the Bayesian Alternative:Uncertainty in Physics and the Usual Methods of Handling ItA Probabilistic Theory of Measurement UncertaintyA Bayesian Primer:Subjective Probability and Bayes' TheoremProbability Distributions (A Concise Reminder)Bayesian Inference of Continuous QuantitiesGaussian LikelihoodCounting ExperimentsBypassing Bayes' Theorem for Routine ApplicationsBayesian UnfoldingFurther Comments, Examples and Applications:Miscellanea on General Issues in Probability and InferenceCombination of Experimental Results: A Closer LookAsymmetric Uncertainties and Nonlinear PropagationWhich Priors for Frontier Physics?Conclusion:Conclusions and Bibliography Readership: Graduate students and researchers interested in probability and statistics and their applications in science, particularly the evaluation of uncertainty in measurements. Keywords:Probability;Bayesian Statistics;Error Theory;Measurement Uncertainty;MetrologyReviews:“… statistics textbooks must take seriously the need to teach the foundations of statistical reasoning from the beginning … D'Agostini's new book does this admirably, building an edifice of Bayesian statistical reasoning in the physical sciences on solid foundations.”Journal of the American Statistical Association

Making statistical modeling and inference more accessible to ecologists and related scientists, Introduction to Hierarchical Bayesian Modeling for Ecological Data gives readers a flexible and effective framework to learn about complex ecological processes from various sources of data. It also helps readers get started on building their own statistical models. The text begins with simple models that progressively become more complex and realistic through explanatory covariates and intermediate hidden states variables. When fitting the models to data, the authors gradually present the concepts and techniques of the Bayesian paradigm from a practical point of view using real case studies. They emphasize how hierarchical Bayesian modeling supports multidimensional models involving complex interactions between parameters and latent variables. Data sets, exercises, and R and WinBUGS codes are available on the authors’ website.

This book shows how Bayesian statistical modeling provides an intuitive way to organize data, test ideas, investigate competing hypotheses, and assess degrees of confidence of predictions. It also illustrates how conditional reasoning can dismantle a complex reality into more understandable pieces. As conditional reasoning is intimately linked with Bayesian thinking, considering hierarchical models within the Bayesian setting offers a unified and coherent framework for modeling, estimation, and prediction.

Graphical models (e.g., Bayesian and constraint networks, influence diagrams, and Markov decision processes) have become a central paradigm for knowledge representation and reasoning in both artificial intelligence and computer science in general. These models are used to perform many reasoning tasks, such as scheduling, planning and learning, diagnosis and prediction, design, hardware and software verification, and bioinformatics. These problems can be stated as

the formal tasks of constraint satisfaction and satisfiability, combinatorial optimization, and probabilistic inference. It is well known that the tasks are computationally hard, but research during the past three decades has yielded a variety of principles and techniques that significantly advanced the state of the art. In this book we provide comprehensive coverage of the primary exact algorithms for reasoning with such models. The main feature exploited by the algorithms is the model's graph. We present inference-based, message-passing schemes (e.g., variable-elimination) and search-based, conditioning schemes (e.g., cycle-cutset conditioning and AND/OR search). Each class possesses distinguished characteristics and in particular has different time vs. space behavior. We emphasize the dependence of both schemes on few graph parameters such as the treewidth, cycle-cutset, and (the pseudo-tree) height. We believe the principles outlined here would serve well in moving forward to approximation and anytime-based schemes. The target audience of this book is researchers and students in the artificial intelligence and machine learning area, and beyond.

A Critical Introduction

Agency, Complexity and Uncertainty in Migration Studies

Probabilistic Programming and Bayesian Inference

Reasoning with Uncertainty

Modular Bayesian Networks

Principles and Techniques