

# PROBABILISTIC GRAPHICAL MODELS

## PRINCIPLES AND TECHNIQUES



DAPHNE KOLLER AND NIR FRIEDMAN

# Probabilistic Graphical Models Principles

**Mykel J. Kochenderfer**

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## **Probabilistic Graphical Models Principles:**

*Probabilistic Graphical Models* Luis Enrique Sucar, 2020-12-23 This fully updated new edition of a uniquely accessible textbook reference provides a general introduction to probabilistic graphical models PGMs from an engineering perspective It features new material on partially observable Markov decision processes causal graphical models causal discovery and deep learning as well as an even greater number of exercises it also incorporates a software library for several graphical models in Python 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 Topics and features Presents a unified framework encompassing all of the main classes of PGMs Explores the fundamental aspects of representation inference and learning for each technique Examines new material on partially observable Markov decision processes and graphical models Includes a new chapter introducing deep neural networks and their relation with probabilistic graphical models Covers multidimensional Bayesian classifiers relational graphical models and causal models Provides substantial chapter ending exercises suggestions for further reading and ideas for research or programming projects Describes classifiers such as Gaussian Naive Bayes Circular Chain Classifiers and Hierarchical Classifiers with Bayesian Networks Outlines the practical application of the different techniques Suggests possible course outlines for instructors This classroom tested work is suitable as a textbook for an advanced undergraduate or a graduate course in probabilistic graphical models for students of computer science engineering and physics Professionals wishing to apply probabilistic graphical models in their own field or interested in the basis of these techniques will also find the book to be an invaluable reference Dr Luis Enrique Sucar is a Senior Research Scientist at the National Institute for Astrophysics Optics and Electronics INAOE Puebla Mexico He received the National Science Prize en 2016

## **Probabilistic Graphical Models**

Daphne Koller, Nir Friedman, 2009-07-31 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

Probabilistic Graphical Models Ignacio Zurrián, 2025 Foundations of Probabilistic Graphical Models Provide a comprehensive introduction to probabilistic graphical models PGMs including their purpose fundamental concepts and types e.g. Bayesian networks Markov networks Discuss the representation of complex probability distributions and dependencies using graphical structures Graph Theory and Probability Foundations Explore the underlying graph theory and probability principles essential for understanding PGMs Cover topics such as nodes edges directed and undirected graphs conditional independence and joint probability distributions Provide insights into how these principles are used to model real world problems Applications and Case Studies Examine the applications of PGMs in various domains such as machine learning computer vision natural language processing and bioinformatics Provide case studies and examples to illustrate how PGMs are used to solve practical problems and make predictions based on complex data

*Probabilistic Graphical Models for Computer Vision*. Qiang Ji, 2019-12-13 Probabilistic Graphical Models for Computer Vision introduces probabilistic graphical models PGMs for computer vision problems and teaches how to develop the PGM model from training data This book discusses PGMs and their significance in the context of solving computer vision problems giving the basic concepts definitions and properties It also provides a comprehensive introduction to well established theories for different types of PGMs including both directed and undirected PGMs such as Bayesian Networks Markov Networks and their variants

*Probabilistic Graphical Models* Linda C. van der Gaag, Ad J. Feelders, 2014-09-11 This book constitutes the refereed proceedings of the 7th International Workshop on Probabilistic Graphical Models PGM 2014 held in Utrecht The Netherlands in September 2014 The 38 revised full papers presented in this book were carefully reviewed and selected from 44 submissions The papers cover all aspects of graphical models for probabilistic reasoning decision making and learning

Principles of Machine Learning Wenmin Wang, 2024-10-26 Conducting an in depth analysis of machine learning this book proposes three perspectives for studying machine learning the learning frameworks learning paradigms and learning tasks With this categorization the learning frameworks reside within the theoretical perspective the learning paradigms pertain to the methodological perspective and the learning tasks are situated within the problematic perspective Throughout the book a

systematic explication of machine learning principles from these three perspectives is provided interspersed with some examples. The book is structured into four parts encompassing a total of fifteen chapters. The inaugural part titled Perspectives comprises two chapters: an introductory exposition and an exploration of the conceptual foundations. The second part, Frameworks, is subdivided into five chapters, each dedicated to the discussion of a seminal framework: probability, statistics, connectionism, symbolism, and behaviorism. Continuing further, the third part, Paradigms, encompasses four chapters that explain the three paradigms of supervised learning, unsupervised learning, and reinforcement learning, and narrating several quasi-paradigms that emerged in machine learning. Finally, the fourth part, Tasks, comprises four chapters delving into the prevalent learning tasks of classification, regression, clustering, and dimensionality reduction. This book provides a multi-dimensional and systematic interpretation of machine learning, rendering it suitable as a textbook reference for senior undergraduates or graduate students pursuing studies in artificial intelligence, machine learning, data science, computer science, and related disciplines. Additionally, it serves as a valuable reference for those engaged in scientific research and technical endeavors within the realm of machine learning. The translation was done with the help of artificial intelligence. A subsequent human revision was done primarily in terms of content.

*Decision Making Under Uncertainty* Mykel J. Kochenderfer, 2015-07-24. An introduction to decision making under uncertainty from a computational perspective covering both theory and applications ranging from speech recognition to airborne collision avoidance. Many important problems involve decision making under uncertainty that is choosing actions based on often imperfect observations with unknown outcomes. Designers of automated decision support systems must take into account the various sources of uncertainty while balancing the multiple objectives of the system. This book provides an introduction to the challenges of decision making under uncertainty from a computational perspective. It presents both the theory behind decision making models and algorithms and a collection of example applications that range from speech recognition to aircraft collision avoidance. Focusing on two methods for designing decision agents: planning and reinforcement learning, the book covers probabilistic models, introducing Bayesian networks as a graphical model that captures probabilistic relationships between variables; utility theory as a framework for understanding optimal decision making under uncertainty; Markov decision processes as a method for modeling sequential problems; model uncertainty, state uncertainty, and cooperative decision making involving multiple interacting agents. A series of applications shows how the theoretical concepts can be applied to systems for attribute-based person search, speech applications, collision avoidance, and unmanned aircraft persistent surveillance. *Decision Making Under Uncertainty* unifies research from different communities using consistent notation and is accessible to students and researchers across engineering disciplines who have some prior exposure to probability theory and calculus. It can be used as a text for advanced undergraduate and graduate students in fields including computer science, aerospace, and electrical engineering and management science. It will also be a valuable professional reference for researchers in a variety of

disciplines **Learning Theory from First Principles** Francis Bach,2024-12-24 A comprehensive and cutting edge introduction to the foundations and modern applications of learning theory Research has exploded in the field of machine learning resulting in complex mathematical arguments that are hard to grasp for new comers In this accessible textbook Francis Bach presents the foundations and latest advances of learning theory for graduate students as well as researchers who want to acquire a basic mathematical understanding of the most widely used machine learning architectures Taking the position that learning theory does not exist outside of algorithms that can be run in practice this book focuses on the theoretical analysis of learning algorithms as it relates to their practical performance Bach provides the simplest formulations that can be derived from first principles constructing mathematically rigorous results and proofs without overwhelming students Provides a balanced and unified treatment of most prevalent machine learning methods Emphasizes practical application and features only commonly used algorithmic frameworks Covers modern topics not found in existing texts such as overparameterized models and structured prediction Integrates coverage of statistical theory optimization theory and approximation theory Focuses on adaptivity allowing distinctions between various learning techniques Hands on experiments illustrative examples and accompanying code link theoretical guarantees to practical behaviors

**Probabilistic Graphical Models and Algorithms for Genomic Analysis** Poe Xing,2004 *Learning Probabilistic Graphical Models in R* David Bellot,2016-04-29 Familiarize yourself with probabilistic graphical models through real world problems and illustrative code examples in R About This Book Predict and use a probabilistic graphical models PGM as an expert system Comprehend how your computer can learn Bayesian modeling to solve real world problems Know how to prepare data and feed the models by using the appropriate algorithms from the appropriate R package Who This Book Is For This book is for anyone who has to deal with lots of data and draw conclusions from it especially when the data is noisy or uncertain Data scientists machine learning enthusiasts engineers and those who curious about the latest advances in machine learning will find PGM interesting What You Will Learn Understand the concepts of PGM and which type of PGM to use for which problem Tune the model s parameters and explore new models automatically Understand the basic principles of Bayesian models from simple to advanced Transform the old linear regression model into a powerful probabilistic model Use standard industry models but with the power of PGM Understand the advanced models used throughout today s industry See how to compute posterior distribution with exact and approximate inference algorithms In Detail Probabilistic graphical models PGM also known as graphical models are a marriage between probability theory and graph theory Generally PGMs use a graph based representation Two branches of graphical representations of distributions are commonly used namely Bayesian networks and Markov networks R has many packages to implement graphical models We ll start by showing you how to transform a classical statistical model into a modern PGM and then look at how to do exact inference in graphical models Proceeding we ll introduce you to many modern R packages that will help you to perform inference on the models We

will then run a Bayesian linear regression and you'll see the advantage of going probabilistic when you want to do prediction. Next you'll master using R packages and implementing its techniques. Finally you'll be presented with machine learning applications that have a direct impact in many fields. Here we'll cover clustering and the discovery of hidden information in big data as well as two important methods: PCA and ICA to reduce the size of big problems. Style and approach: This book gives you a detailed and step-by-step explanation of each mathematical concept which will help you build and analyze your own machine learning models and apply them to real-world problems. The mathematics is kept simple and each formula is explained thoroughly.

**Building Tractable Probabilistic Graphical Models for Computer Vision Problems** Xiangyang Lan, 2007 *Science*, 2011 **Statistical Methods for Comparing Genomes** Jon David McAuliffe, 2005

**Graphical Models** Christian Borgelt, Rudolf Kruse, 2002-03-15 The concept of modelling using graph theory has its origin in several scientific areas notably statistics, physics, genetics, and engineering. The use of graphical models in applied statistics has increased considerably over recent years and the theory has been greatly developed and extended. This book provides a self-contained introduction to the learning of graphical models from data and is the first to include detailed coverage of probabilistic networks, a relatively new reasoning tool that allows the user to infer results from problems with imprecise data. One major advantage of graphical modelling is that specialised techniques that have been developed in one field can be transferred into others easily. The methods described here are applied in a number of industries including a recent quality testing programme at a major car manufacturer. Provides a self-contained introduction to learning relational probabilistic and probabilistic networks from data. Each concept is carefully explained and illustrated by examples. Contains all necessary background including modeling under uncertainty, decomposition of distributions, and graphical representation of decompositions. Features applications of learning graphical models from data and problems for further research. Includes a comprehensive bibliography. An essential reference for graduate students of graphical modelling, applied statistics, computer science, and engineering, as well as researchers and practitioners who use graphical models in their work. Cornell University Courses of Study Cornell University, 2007 **Graphical Models in Applied Multivariate Statistics** J.

Whittaker, 1990 Graphical models, a subset of log-linear models, reveal the interrelationships between multiple variables and features of the underlying conditional independence. Following the theorem-proof-remarks format, this introduction to the use of graphical models in the description and modeling of multivariate systems covers conditional independence, several types of independence graphs, Gaussian models, issues in model selection, regression, and decomposition. Many numerical examples and exercises with solutions are included. **Iris**, 2009 [cyberspace](#), 2018-05-01 *Statistica Sinica*, 2008 **Proceedings**, 2005

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