# Statistical Relational Artificial Intelligence Logic Probability And Computation Synthesis Lectures On Artificial Intelligence And Machine Learning

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Inductive Logic Programming
Transfer Learning, Structure Learning, and an Application to Web Query Disambiguation
Boosted Statistical Relational Learners

## JERAMIAH BRAYLON

*Inductive Logic Programming* Morgan Kaufmann
This book constitutes the thoroughly refereed post-proceedings of the 23rd International Conference on Inductive Logic Programming, ILP 2013, held in Rio de Janeiro, Brazil, in August 2013. The 9 revised extended papers were carefully reviewed and selected from 42 submissions. The conference now focuses on all aspects of learning in logic, multi-relational learning and data mining, statistical relational learning, graph and tree mining, relational reinforcement learning, and other forms of learning from structured data.
From Theory to Algorithms Springer
An intelligent agent interacting with the real world will encounter individual people, courses, test results, drugs prescriptions, chairs, boxes, etc., and needs to reason about properties of these individuals and relations among them as well as cope with uncertainty. Uncertainty has been studied in probability theory and graphical

models, and relations have been studied in logic, in particular in the predicate calculus and its extensions. This book examines the foundations of combining logic and probability into what are called relational probabilistic models. It introduces representations, inference, and learning techniques for probability, logic, and their combinations. The book focuses on two representations in detail: Markov logic networks, a relational extension of undirected graphical models and weighted first-order predicate calculus formula, and Problog, a probabilistic extension of logic programs that can also be viewed as a Turing-complete relational extension of Bayesian networks.

Logical Foundations of Artificial Intelligence

Springer Nature

Traditionally, machine learning algorithms assume that training data is provided as a set of independent instances, each of which can be described as a feature vector. In contrast, many domains of interest are inherently multi-relational, consisting of entities connected by a rich set of relations. For example, the participants in a social network are linked by friendships, collaborations, and shared interests. Likewise, the users of a search engine are related by searches for similar items and clicks to shared sites. The ability to model and reason about such relations is essential not only because better

predictive accuracy is achieved by exploiting this additional information, but also because frequently the goal is to predict whether a set of entities are related in a particular way. This thesis falls within the area of Statistical Relational Learning (SRL), which combines ideas from two traditions within artificial intelligence, first-order logic and probabilistic graphical models to address the challenge of learning from multi-relational data. We build on one particular SRL model, Markov logic networks (MLNs), which consist of a set of weighted first-order-logic formulae and provide a principled way of defining a probability distribution over possible worlds. We develop algorithms for learning of MLN structure both from scratch and by transferring a previously learned model, as well as an application of MLNs to the problem of Web query disambiguation. The ideas we present are unified by two main themes: the need to deal with limited training data and the use of bottom-up learning techniques. Structure learning, the task of automatically acquiring a set of dependencies among the relations in the domain, is a central problem in SRL. We introduce BUSL, an algorithm for learning MLN structure from scratch that proceeds in a more bottom-up fashion, breaking away from the tradition of top-down learning typical in SRL. Our approach first constructs a novel data structure called a Markov

network template that is used to restrict the search space for clauses. Our experiments in three relational domains demonstrate that BUSL dramatically reduces the search space for clauses and attains a significantly higher accuracy than a structure learner that follows a top-down approach. Accurate and efficient structure learning can also be achieved by transferring a model obtained in a source domain related to the current target domain of interest. We view transfer as a revision task and present an algorithm that diagnoses a source MLN to determine which of its parts transfer directly to the target domain and which need to be updated. This analysis focuses the search for revisions on the incorrect portions of the source structure, thus speeding up learning. Transfer learning is particularly important when target-domain data is limited, such as when data on only a few individuals is available from domains with hundreds of entities connected by a variety of relations. We also address this challenging case and develop a general transfer learning approach that makes effective use of such limited target data in several social network domains. Finally, we develop an application of MLNs to the problem of Web query disambiguation in a more privacy-aware setting where the only information available about a user is that captured in a short search session of 5-6 previous queries on average. This

setting contrasts with previous work that typically assumes the availability of long user-specific search histories. To compensate for the scarcity of user-specific information, our approach exploits the relations between users, search terms, and URLs. We demonstrate the effectiveness of our approach in the presence of noise and show that it outperforms several natural baselines on a large data set collected from the MSN search engine.

*22nd European Conference on Artificial Intelligence, 29 August - 2 September 2016, The Hague, The Netherlands - Including Prestigious Applications of Artificial Intelligence (PAIS 2016)*
Morgan & Claypool Publishers
This book provides a systematic and comprehensive description of Non-Axiomatic Logic, which is the result of the author''s research for about three decades.Non-Axiomatic Logic is designed to provide a uniform logical foundation for Artificial Intelligence, as well as an abstract description of the OC laws of thoughtOCO followed by the human mind. Different from OC mathematicalOCO logic, where the focus is the regularity required when demonstrating mathematical conclusions, Non-Axiomatic Logic is an attempt to return to the original aim of logic, that is, to formulate the regularity in actual human thinking. To achieve this goal, the logic is designed under the assumption

that the system has insufficient knowledge and resources with respect to the problems to be solved, so that the OC logical conclusionsOCO are only valid with respect to the available knowledge and resources. Reasoning processes according to this logic covers cognitive functions like learning, planning, decision making, problem solving, This book is written for researchers and students in Artificial Intelligence and Cognitive Science, and can be used as a textbook for courses at graduate level, or upper-level undergraduate, on Non-Axiomatic Logic."

Springer Science & Business Media

Talks about Logic Programming, Uncertainty Reasoning and Machine Learning. This book includes definitions that circumscribe the area formed by extending Inductive Logic Programming to cases annotated with probability values. It investigates the approach of Learning from proofs and the issue of upgrading Fisher Kernels to Relational Fisher Kernels.

**The Master Algorithm**

World Scientific

This comprehensive encyclopedia, in A-Z format, provides easy access to relevant information for those seeking entry into any aspect within the broad field of Machine Learning. Most of the entries in this preeminent work include useful literature references.

Inductive Logic Programming Morgan & Claypool Publishers

The three volume

proceedings LNAI 10534 – 10536 constitutes the refereed proceedings of the European Conference on Machine Learning and Knowledge Discovery in Databases, ECML PKDD 2017, held in Skopje, Macedonia, in September 2017. The total of 101 regular papers presented in part I and part II was carefully reviewed and selected from 364 submissions; there are 47 papers in the applied data science, nectar and demo track. The contributions were organized in topical sections named as follows: Part I: anomaly detection; computer vision; ensembles and meta learning; feature selection and extraction; kernel methods; learning and optimization, matrix and tensor factorization; networks and graphs; neural networks and deep learning. Part II: pattern and sequence mining; privacy and security; probabilistic models and methods; recommendation; regression; reinforcement learning; subgroup discovery; time series and streams; transfer and multi-task learning; unsupervised and semisupervised learning. Part III: applied data science track; nectar track; and demo track.

*30th International Conference, ILP 2021, Virtual Event, October 25–27, 2021, Proceedings*

Springer

Phase transitions typically occur in combinatorial computational problems and have important consequences, especially with the current spread of statistical relational learning as well as sequence learning

methodologies. In Phase Transitions in Machine Learning the authors begin by describing in detail this phenomenon, and the extensive experimental investigation that supports its presence. They then turn their attention to the possible implications and explore appropriate methods for tackling them. Weaving together fundamental aspects of computer science, statistical physics and machine learning, the book provides sufficient mathematics and physics background to make the subject intelligible to researchers in AI and other computer science communities. Open research issues are also discussed, suggesting promising directions for future research. Learning with Markov Logic Networks Springer Introduces machine learning and its algorithmic paradigms, explaining the principles behind automated learning approaches and the considerations underlying their usage. **Markov Logic** Morgan & Claypool Publishers Artificial intelligence (AI) plays a vital part in the continued development of computer science and informatics. The AI applications employed in fields such as medicine, economics, linguistics, philosophy, psychology and logical analysis, not forgetting industry, are now indispensable for the effective functioning of a multitude of systems. This book presents the papers from the 20th biennial European Conference on Artificial Intelligence, ECAI 2012, held in Montpellier,

France, in August 2012. The ECAI conference remains Europe's principal opportunity for researchers and practitioners of Artificial Intelligence to gather and to discuss the latest trends and challenges in all subfields of AI, as well as to demonstrate innovative applications and uses of advanced AI technology. ECAI 2012 featured four keynote speakers, an extensive workshop program, seven invited tutorials and the new Frontiers of Artificial Intelligence track, in which six invited speakers delivered perspective talks on particularly interesting new research results, directions and trends in Artificial Intelligence or in one of its related fields. The proceedings of PAIS 2012 and the System Demonstrations Track are also included in this volume, which will be of interest to all those wishing to keep abreast of the latest developments in the field of AI.

**27th International Conference, ILP 2017, Orléans, France, September 4-6, 2017, Revised Selected Papers** Stylus Publishing, LLC

Artificial Intelligence presents a practical guide to AI, including agents, machine learning and problem-solving simple and complex domains.

**Scalable Uncertainty Management** Springer

Intended both as a text for advanced undergraduates and graduate students, and as a key reference work for AI researchers and developers, Logical Foundations of Artificial

Intelligence is a lucid, rigorous, and comprehensive account of the fundamentals of artificial intelligence from the standpoint of logic. The first section of the book introduces the logicist approach to AI--discussing the representation of declarative knowledge and featuring an introduction to the process of conceptualization, the syntax and semantics of predicate calculus, and the basics of other declarative representations such as frames and semantic nets. This section also provides a simple but powerful inference procedure, resolution, and shows how it can be used in a reasoning system. The next several chapters discuss nonmonotonic reasoning, induction, and reasoning under uncertainty, broadening the logical approach to deal with the inadequacies of strict logical deduction. The third section introduces modal operators that facilitate representing and reasoning about knowledge. This section also develops the process of writing predicate calculus sentences to the metalevel--to permit sentences about sentences and about reasoning processes. The final three chapters discuss the representation of knowledge about states and actions, planning, and intelligent system architecture. End-of-chapter bibliographic and historical comments provide background and point to other works of interest and research.

Each chapter also contains numerous student exercises (with solutions provided in an appendix) to reinforce concepts and challenge the learner. A bibliography and index complete this comprehensive work.
A Model of Intelligent Reasoning Springer Nature
Neuro-symbolic AI is an emerging subfield of Artificial Intelligence that brings together two hitherto distinct approaches. ”Neuro” refers to the artificial neural networks prominent in machine learning, ”symbolic” refers to algorithmic processing on the level of meaningful symbols, prominent in knowledge representation. In the past, these two fields of AI have been largely separate, with very little crossover, but the so-called “third wave” of AI is now bringing them together. This book, Neuro-Symbolic Artificial Intelligence: The State of the Art, provides an overview of this development in AI. The two approaches differ significantly in terms of their strengths and weaknesses and, from a cognitive-science perspective, there is a question as to how a neural system can perform symbol manipulation, and how the representational differences between these two approaches can be bridged. The book presents 17 overview papers, all by authors who have made significant contributions in the past few years and starting with a historic overview

first seen in 2016. With just seven months elapsed from invitation to authors to final copy, the book is as up-to-date as a published overview of this subject can be. Based on the editors' own desire to understand the current state of the art, this book reflects the breadth and depth of the latest developments in neuro-symbolic AI, and will be of interest to students, researchers, and all those working in the field of Artificial Intelligence.

*European Conference, ECML PKDD 2017, Skopje, Macedonia, September 18–22, 2017, Proceedings, Part I* Cambridge University Press

This book provides an introduction to probabilistic inductive logic programming. It places emphasis on the methods based on logic programming principles and covers formalisms and systems, implementations and applications, as well as theory.

Inductive Logic Programming IOS Press

The increasing abundance of large high-quality datasets, combined with significant technical advances over the last several decades have made machine learning into a major tool employed across a broad array of tasks including vision, language, finance, and security. However, success has been accompanied with important new challenges: many applications of machine learning are adversarial in nature. Some are adversarial because they are safety critical, such as autonomous driving. An

adversary in these applications can be a malicious party aimed at causing congestion or accidents, or may even model unusual situations that expose vulnerabilities in the prediction engine. Other applications are adversarial because their task and/or the data they use are. For example, an important class of problems in security involves detection, such as malware, spam, and intrusion detection. The use of machine learning for detecting malicious entities creates an incentive among adversaries to evade detection by changing their behavior or the content of malicius objects they develop. The field of adversarial machine learning has emerged to study vulnerabilities of machine learning approaches in adversarial settings and to develop techniques to make learning robust to adversarial manipulation. This book provides a technical overview of this field. After reviewing machine learning concepts and approaches, as well as common use cases of these in adversarial settings, we present a general categorization of attacks on machine learning. We then address two major categories of attacks and associated defenses: decision-time attacks, in which an adversary changes the nature of instances seen by a learned model at the time of prediction in order to cause errors, and poisoning or training time attacks, in which the actual training dataset is maliciously modified. In

our final chapter devoted to technical content, we discuss recent techniques for attacks on deep learning, as well as approaches for improving robustness of deep neural networks. We conclude with a discussion of several important issues in the area of adversarial learning that in our view warrant further research. Given the increasing interest in the area of adversarial machine learning, we hope this book provides readers with the tools necessary to successfully engage in research and practice of machine learning in adversarial settings.

*Probabilistic Inductive Logic Programming* Statistical Relational Artificial IntelligenceLogic, Probability, and Computation This first textbook on multi-relational data mining and inductive logic programming provides a complete overview of the field. It is self-contained and easily accessible for graduate students and practitioners of data mining and machine learning.

*15th European Conference, JELIA 2016, Larnaca, Cyprus, November 9-11, 2016, Proceedings* IOS Press Advanced statistical modeling and knowledge representation techniques for a newly emerging area of machine learning and probabilistic reasoning; includes introductory material, tutorials for different proposed approaches, and applications. Handling inherent uncertainty and exploiting compositional structure are fundamental to understanding and

designing large-scale systems. Statistical relational learning builds on ideas from probability theory and statistics to address uncertainty while incorporating tools from logic, databases and programming languages to represent structure. In Introduction to Statistical Relational Learning, leading researchers in this emerging area of machine learning describe current formalisms, models, and algorithms that enable effective and robust reasoning about richly structured systems and data. The early chapters provide tutorials for material used in later chapters, offering introductions to representation, inference and learning in graphical models, and logic. The book then describes object-oriented approaches, including probabilistic relational models, relational Markov networks, and probabilistic entity-relationship models as well as logic-based formalisms including Bayesian logic programs, Markov logic, and stochastic logic programs. Later chapters discuss such topics as probabilistic models with unknown objects, relational dependency networks, reinforcement learning in relational domains, and information extraction. By presenting a variety of approaches, the book highlights commonalities and clarifies important differences among proposed approaches and, along the way, identifies important representational and algorithmic issues.

Numerous applications are provided throughout. **European Conference, ECML PKDD 2018, Dublin, Ireland, September 10–14, 2018, Proceedings, Part II** Cambridge University Press
The theory and practice of AI and ML in marketing saving time, money **Encyclopedia of Machine Learning** Springer
This book constitutes the refereed proceedings of the 14th International Conference on Scalable Uncertainty Management, SUM 2020, which was held in Bozen-Bolzano, Italy, in September 2020. The 12 full, 7 short papers presented in this volume were carefully reviewed and selected from 30 submissions. Besides that, the book also contains 2 abstracts of invited talks, 2 tutorial papers, and 2 PhD track papers. The conference aims to gather researchers with a common interest in managing and analyzing imperfect information from a wide range of fields, such as artificial intelligence and machine learning, databases, information retrieval and data mining, the semantic web and risk analysis. Due to the Corona pandemic SUM 2020 was held as an virtual event. **Understanding Machine Learning** Basic Books
The question, how to combine probability and logic with learning, is getting an increased attention in several disciplines such as knowledge representation, reasoning about uncertainty, data mining, and machine

learning simulateously. This results in the newly emerging subfield known under the names of statistical relational learning and probabilistic inductive logic programming. This book provides an introduction to the field with an emphasis on the methods based on logic programming principles. It is concerned with formalisms and systems, implementations and applications, as well as with the theory of probabilistic inductive logic programming. The 13 chapters of this state-of-the-art survey start with an introduction to probabilistic inductive logic programming; moreover the book presents a detailed overview of the most important probabilistic logic learning formalisms and systems such as relational sequence learning techniques, using kernels with logical representations, Markov logic, the PRISM system, CLP(BN), Bayesian logic programs, and the independent choice logic. The third part provides a detailed account of some show-case applications of probabilistic inductive logic programming. The final part touches upon some theoretical investigations and includes chapters on behavioural comparison of probabilistic logic programming representations and a model-theoretic expressivity analysis.

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