Pedro Domingos · Daniel Lowd

Markov Logic:
An Interface Layer for
Artificial Intelligence

Markov Logic An Interface Layer For Artificial Intelligence Daniel Lowd

Mausam Natarajan,Andrey Kolobov

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Markov Logic Pedro Domingos,Daniel Lowd,2009-05-08 Most subfields of computer science have an interface layer via which applications communicate with the infrastructure and this is key to their success e g the Internet in networking the relational model in databases etc So far this interface layer has been missing in AI First order logic and probabilistic graphical models each have some of the necessary features but a viable interface layer requires combining both Markov logic is a powerful new language that accomplishes this by attaching weights to first order formulas and treating them as templates for features of Markov random fields Most statistical models in wide use are special cases of Markov logic and first order logic is its infinite weight limit Inference algorithms for Markov logic combine ideas from satisfiability Markov chain Monte Carlo belief propagation and resolution Learning algorithms make use of conditional likelihood convex optimization and inductive logic programming Markov logic has been successfully applied to problems in information extraction and integration natural language processing robot mapping social networks computational biology and others and is the basis of the open source Alchemy system **Markov Logic** Pedro Domingos,Daniel Lowd,2022-05-31 Most subfields of computer science have an interface layer via which applications communicate with the infrastructure and this is key to their success e g the Internet in networking the relational model in databases etc So far this interface layer has been missing in AI First order logic and probabilistic graphical models each have some of the necessary features but a viable interface layer requires combining both Markov logic is a powerful new language that accomplishes this by attaching weights to first order formulas and treating them as templates for features of Markov random fields Most statistical models in wide use are special cases of Markov logic and first order logic is its infinite weight limit Inference algorithms for Markov logic combine ideas from satisfiability Markov chain Monte Carlo belief propagation and resolution Learning algorithms make use of conditional likelihood convex optimization and inductive logic programming Markov logic has been successfully applied to problems in information extraction and integration natural language processing robot mapping social networks computational biology and others and is the basis of the open source Alchemy system Table of Contents Introduction Markov Logic Inference Learning Extensions Applications Conclusion **Knowledge Representation, Reasoning, and the Design of Intelligent Agents** Michael Gelfond,Yulia Kahl,2014-03-10 This in depth introduction for students and researchers shows how to use ASP for intelligent tasks including answering queries planning and diagnostics **Adversarial Machine Learning** Yevgeniy Vorobeychik,Murat Kantarcioglu,2022-05-31 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   Lifelong Machine Learning, Second Edition Zhiyuan Chen,Bing Liu,2022-06-01 Lifelong Machine Learning Second Edition is an introduction to an advanced machine learning paradigm that continuously learns by accumulating past knowledge that it then uses in future learning and problem solving In contrast the current dominant machine learning paradigm learns in isolation given a training dataset it runs a machine learning algorithm on the dataset to produce a model that is then used in its intended application It makes no attempt to retain the learned knowledge and use it in subsequent learning Unlike this isolated system humans learn effectively with only a few examples precisely because our learning is very knowledge driven the knowledge learned in the past helps us learn new things with little data or effort Lifelong learning aims to emulate this capability because without it an AI system cannot be considered truly intelligent Research in lifelong learning has developed significantly in the relatively short time since the first edition of this book was published The purpose of this second edition is to expand the definition of lifelong learning update the content of several chapters and add a new chapter about continual learning in deep neural networks which has been actively researched over the past two or three years A few chapters have also been reorganized to make each of them more coherent for the reader Moreover the authors want to propose a unified framework for the research area Currently there are several research topics in machine learning that are closely related to lifelong learning most notably multi task learning transfer learning and meta learning because they also employ the idea of knowledge sharing and transfer This book brings all these topics under one

roof and discusses their similarities and differences Its goal is to introduce this emerging machine learning paradigm and present a comprehensive survey and review of the important research results and latest ideas in the area This book is thus suitable for students researchers and practitioners who are interested in machine learning data mining natural language processing or pattern recognition Lecturers can readily use the book for courses in any of these related fields   <u>Planning with Markov Decision Processes</u> Mausam Natarajan,Andrey Kolobov,2022-06-01 Markov Decision Processes MDPs are widely popular in Artificial Intelligence for modeling sequential decision making scenarios with probabilistic dynamics They are the framework of choice when designing an intelligent agent that needs to act for long periods of time in an environment where its actions could have uncertain outcomes MDPs are actively researched in two related subareas of AI probabilistic planning and reinforcement learning Probabilistic planning assumes known models for the agent s goals and domain dynamics and focuses on determining how the agent should behave to achieve its objectives On the other hand reinforcement learning additionally learns these models based on the feedback the agent gets from the environment This book provides a concise introduction to the use of MDPs for solving probabilistic planning problems with an emphasis on the algorithmic perspective It covers the whole spectrum of the field from the basics to state of the art optimal and approximation algorithms We first describe the theoretical foundations of MDPs and the fundamental solution techniques for them We then discuss modern optimal algorithms based on heuristic search and the use of structured representations A major focus of the book is on the numerous approximation schemes for MDPs that have been developed in the AI literature These include determinization based approaches sampling techniques heuristic functions dimensionality reduction and hierarchical representations Finally we briefly introduce several extensions of the standard MDP classes that model and solve even more complex planning problems Table of Contents Introduction MDPs Fundamental Algorithms Heuristic Search Algorithms Symbolic Algorithms Approximation Algorithms Advanced Notes   <u>Data Integration</u> Michael Genesereth,2022-05-31 Data integration is a critical problem in our increasingly interconnected but inevitably heterogeneous world There are numerous data sources available in organizational databases and on public information systems like the World Wide Web Not surprisingly the sources often use different vocabularies and different data structures being created as they are by different people at different times for different purposes The goal of data integration is to provide programmatic and human users with integrated access to multiple heterogeneous data sources giving each user the illusion of a single homogeneous database designed for his or her specific need The good news is that in many cases the data integration process can be automated This book is an introduction to the problem of data integration and a rigorous account of one of the leading approaches to solving this problem viz the relational logic approach Relational logic provides a theoretical framework for discussing data integration Moreover in many important cases it provides algorithms for solving the problem in a computationally practical way In many respects relational logic does for data integration what relational algebra did for database theory several decades ago A

companion web site provides interactive demonstrations of the algorithms Table of Contents Preface Interactive Edition Introduction Basic Concepts Query Folding Query Planning Master Schema Management Appendix References Index Author Biography Don t have access Recommend our Synthesis Digital Library to your library or purchase a personal subscription Email info morganclaypool com for details   Introduction to Logic Programming Michael Genesereth,Vinay K. Chaudhri,2022-06-01 Logic Programming is a style of programming in which programs take the form of sets of sentences in the language of Symbolic Logic Over the years there has been growing interest in Logic Programming due to applications in deductive databases automated worksheets Enterprise Management business rules Computational Law and General Game Playing This book introduces Logic Programming theory current technology and popular applications In this volume we take an innovative model theoretic approach to logic programming We begin with the fundamental notion of datasets i e sets of ground atoms Given this fundamental notion we introduce views i e virtual relations and we define classical logic programs as sets of view definitions written using traditional Prolog like notation but with semantics given in terms of datasets rather than implementation We then introduce actions i e additions and deletions of ground atoms and we define dynamic logic programs as sets of action definitions In addition to the printed book there is an online version of the text with an interpreter and a compiler for the language used in the text and an integrated development environment for use in developing and deploying practical logic programs   **Explainable Human-AI Interaction** Sarath Sreedharan,Anagha Kulkarni,Subbarao Kambhampati,2022-01-24 From its inception artificial intelligence AI has had a rather ambivalent relationship with humans swinging between their augmentation and replacement Now as AI technologies enter our everyday lives at an ever increasing pace there is a greater need for AI systems to work synergistically with humans One critical requirement for such synergistic human AI interaction is that the AI systems behavior be explainable to the humans in the loop To do this effectively AI agents need to go beyond planning with their own models of the world and take into account the mental model of the human in the loop At a minimum AI agents need approximations of the human s task and goal models as well as the human s model of the AI agent s task and goal models The former will guide the agent to anticipate and manage the needs desires and attention of the humans in the loop and the latter allow it to act in ways that are interpretable to humans by conforming to their mental models of it and be ready to provide customized explanations when needed The authors draw from several years of research in their lab to discuss how an AI agent can use these mental models to either conform to human expectations or change those expectations through explanatory communication While the focus of the book is on cooperative scenarios it also covers how the same mental models can be used for obfuscation and deception The book also describes several real world application systems for collaborative decision making that are based on the framework and techniques developed here Although primarily driven by the authors own research in these areas every chapter will provide ample connections to relevant research from the wider literature The technical topics covered in the book are self contained and are accessible to readers

with a basic background in AI **Algorithms for Reinforcement Learning** Csaba Szepesvári,2022-05-31 Reinforcement learning is a learning paradigm concerned with learning to control a system so as to maximize a numerical performance measure that expresses a long term objective What distinguishes reinforcement learning from supervised learning is that only partial feedback is given to the learner about the learner s predictions Further the predictions may have long term effects through influencing the future state of the controlled system Thus time plays a special role The goal in reinforcement learning is to develop efficient learning algorithms as well as to understand the algorithms merits and limitations Reinforcement learning is of great interest because of the large number of practical applications that it can be used to address ranging from problems in artificial intelligence to operations research or control engineering In this book we focus on those algorithms of reinforcement learning that build on the powerful theory of dynamic programming We give a fairly comprehensive catalog of learning problems describe the core ideas note a large number of state of the art algorithms followed by the discussion of their theoretical properties and limitations Table of Contents Markov Decision Processes Value Prediction Problems Control For Further Exploration **Introduction to Intelligent Systems in Traffic and Transportation** Ana L.C. Bazzan,Franziska Klügl,2022-05-31 Urban mobility is not only one of the pillars of modern economic systems but also a key issue in the quest for equality of opportunity once it can improve access to other services Currently however there are a number of negative issues related to traffic especially in mega cities such as economical issues cost of opportunity caused by delays environmental externalities related to emissions of pollutants and social traffic accidents Solutions to these issues are more and more closely tied to information and communication technology Indeed a search in the technical literature using the keyword urban traffic to filter out articles on data network traffic retrieved the following number of articles as of December 3 2013 9 443 ACM Digital Library 26 054 Scopus and 1 730 000 Google Scholar Moreover articles listed in the ACM query relate to conferences as diverse as MobiCom CHI PADS and AAMAS This means that there is a big and diverse community of computer scientists and computer engineers who tackle research that is connected to the development of intelligent traffic and transportation systems It is also possible to see that this community is growing and that research projects are getting more and more interdisciplinary To foster the cooperation among the involved communities this book aims at giving a broad introduction into the basic but relevant concepts related to transportation systems targeting researchers and practitioners from computer science and information technology In addition the second part of the book gives a panorama of some of the most exciting and newest technologies originating in computer science and computer engineering that are now being employed in projects related to car to car communication interconnected vehicles car navigation platooning crowd sensing and sensor networks among others This material will also be of interest to engineers and researchers from the traffic and transportation community **Transfer Learning for Multiagent Reinforcement Learning Systems** Felipe Leno da Silva,Anna Helena Reali Costa,2022-06-01 Learning to solve sequential decision making

tasks is difficult Humans take years exploring the environment essentially in a random way until they are able to reason solve difficult tasks and collaborate with other humans towards a common goal Artificial Intelligent agents are like humans in this aspect Reinforcement Learning RL is a well known technique to train autonomous agents through interactions with the environment Unfortunately the learning process has a high sample complexity to infer an effective actuation policy especially when multiple agents are simultaneously actuating in the environment However previous knowledge can be leveraged to accelerate learning and enable solving harder tasks In the same way humans build skills and reuse them by relating different tasks RL agents might reuse knowledge from previously solved tasks and from the exchange of knowledge with other agents in the environment In fact virtually all of the most challenging tasks currently solved by RL rely on embedded knowledge reuse techniques such as Imitation Learning Learning from Demonstration and Curriculum Learning This book surveys the literature on knowledge reuse in multiagent RL The authors define a unifying taxonomy of state of the art solutions for reusing knowledge providing a comprehensive discussion of recent progress in the area In this book readers will find a comprehensive discussion of the many ways in which knowledge can be reused in multiagent sequential decision making tasks as well as in which scenarios each of the approaches is more efficient The authors also provide their view of the current low hanging fruit developments of the area as well as the still open big questions that could result in breakthrough developments Finally the book provides resources to researchers who intend to join this area or leverage those techniques including a list of conferences journals and implementation tools This book will be useful for a wide audience and will hopefully promote new dialogues across communities and novel developments in the area   *Strategic Voting* Reshef Meir,2022-05-31 Social choice theory deals with aggregating the preferences of multiple individuals regarding several available alternatives a situation colloquially known as voting There are many different voting rules in use and even more in the literature owing to the various considerations such an aggregation method should take into account The analysis of voting scenarios becomes particularly challenging in the presence of strategic voters that is voters that misreport their true preferences in an attempt to obtain a more favorable outcome In a world that is tightly connected by the Internet where multiple groups with complex incentives make frequent joint decisions the interest in strategic voting exceeds the scope of political science and is a focus of research in economics game theory sociology mathematics and computer science The book has two parts The first part asks are there voting rules that are truthful in the sense that all voters have an incentive to report their true preferences The seminal Gibbard Satterthwaite theorem excludes the existence of such voting rules under certain requirements From this starting point we survey both extensions of the theorem and various conditions under which truthful voting is made possible such as restricted preference domains We also explore the connections with other problems of mechanism design such as locating a facility that serves multiple users In the second part we ask what would be the outcome when voters do vote strategically rather than trying to prevent such behavior We overview various game theoretic

models and equilibrium concepts from the literature demonstrate how they apply to voting games and discuss their implications on social welfare We conclude with a brief survey of empirical and experimental findings that could play a key role in future development of game theoretic voting models **An Introduction to Constraint-Based Temporal Reasoning** Roman Barták,Robert A. Morris,K. Brent Venable,2022-05-31 Solving challenging computational problems involving time has been a critical component in the development of artificial intelligence systems almost since the inception of the field This book provides a concise introduction to the core computational elements of temporal reasoning for use in AI systems for planning and scheduling as well as systems that extract temporal information from data It presents a survey of temporal frameworks based on constraints both qualitative and quantitative as well as of major temporal consistency techniques The book also introduces the reader to more recent extensions to the core model that allow AI systems to explicitly represent temporal preferences and temporal uncertainty This book is intended for students and researchers interested in constraint based temporal reasoning It provides a self contained guide to the different representations of time as well as examples of recent applications of time in AI systems **On Computing** Paul S. Rosenbloom,2012-11-09 A proposal that computing is not merely a form of engineering but a scientific domain on a par with the physical life and social sciences Computing is not simply about hardware or software or calculation or applications Computing writes Paul Rosenbloom is an exciting and diverse yet remarkably coherent scientific enterprise that is highly multidisciplinary yet maintains a unique core of its own In On Computing Rosenbloom proposes that computing is a great scientific domain on a par with the physical life and social sciences Rosenbloom introduces a relational approach for understanding computing conceptualizing it in terms of forms of interaction and implementation to reveal the hidden structures and connections among its disciplines He argues for the continuing vitality of computing surveying the leading edge in computing s combination with other domains from biocomputing and brain computer interfaces to crowdsourcing and virtual humans to robots and the intermingling of the real and the virtual He explores forms of higher order coherence or macrostructures over complex computing topics and organizations Finally he examines the very notion of a great scientific domain in philosophical terms honing his argument that computing should be considered the fourth great scientific domain With On Computing Rosenbloom a key architect of the founding of University of Southern California s Institute for Creative Technologies and former Deputy Director of USC s Information Sciences Institute offers a broader perspective on what computing is and what it can become **Introduction to Graph Neural Networks** Zhiyuan Liu,Jie Zhou,2022-05-31 Graphs are useful data structures in complex real life applications such as modeling physical systems learning molecular fingerprints controlling traffic networks and recommending friends in social networks However these tasks require dealing with non Euclidean graph data that contains rich relational information between elements and cannot be well handled by traditional deep learning models e g convolutional neural networks CNNs or recurrent neural networks RNNs Nodes in graphs usually contain useful

feature information that cannot be well addressed in most unsupervised representation learning methods e g network embedding methods Graph neural networks GNNs are proposed to combine the feature information and the graph structure to learn better representations on graphs via feature propagation and aggregation Due to its convincing performance and high interpretability GNN has recently become a widely applied graph analysis tool This book provides a comprehensive introduction to the basic concepts models and applications of graph neural networks It starts with the introduction of the vanilla GNN model Then several variants of the vanilla model are introduced such as graph convolutional networks graph recurrent networks graph attention networks graph residual networks and several general frameworks Variants for different graph types and advanced training methods are also included As for the applications of GNNs the book categorizes them into structural non structural and other scenarios and then it introduces several typical models on solving these tasks Finally the closing chapters provide GNN open resources and the outlook of several future directions *Trading Agents* Michael P. Wellman,2011 Automated trading in electronic markets is one of the most common and consequential applications of autonomous software agents Design of effective trading strategies requires thorough understanding of how market mechanisms operate and appreciation of strategic issues that commonly manifest in trading scenarios Drawing on research in auction theory and artificial intelligence this book presents core principles of strategic reasoning that apply to market situations The author illustrates trading strategy choices through examples of concrete market environments such as eBay as well as abstract market models defined by configurations of auctions and traders Techniques for addressing these choices constitute essential building blocks for the design of trading strategies for rich market applications The lecture assumes no prior background in game theory or auction theory or artificial intelligence Table of Contents Introduction Example Bidding on eBay Auction Fundamentals Continuous Double Auctions Interdependent Markets Conclusion **Human Computation** Edith Law,Luis von Ahn,2022-06-01 Human computation is a new and evolving research area that centers around harnessing human intelligence to solve computational problems that are beyond the scope of existing Artificial Intelligence AI algorithms With the growth of the Web human computation systems can now leverage the abilities of an unprecedented number of people via the Web to perform complex computation There are various genres of human computation applications that exist today Games with a purpose e g the ESP Game specifically target online gamers who generate useful data e g image tags while playing an enjoyable game Crowdsourcing marketplaces e g Amazon Mechanical Turk are human computation systems that coordinate workers to perform tasks in exchange for monetary rewards In identity verification tasks users perform computation in order to gain access to some online content an example is reCAPTCHA which leverages millions of users who solve CAPTCHAs every day to correct words in books that optical character recognition OCR programs fail to recognize with certainty This book is aimed at achieving four goals 1 defining human computation as a research area 2 providing a comprehensive review of existing work 3 drawing connections to a wide variety of disciplines including AI Machine Learning

HCI Mechanism Market Design and Psychology and capturing their unique perspectives on the core research questions in human computation and 4 suggesting promising research directions for the future Table of Contents Introduction Human Computation Algorithms Aggregating Outputs Task Routing Understanding Workers and Requesters The Art of Asking Questions The Future of Human Computation   *Trading Agents* Michael Wellman,2022-05-31 Automated trading in electronic markets is one of the most common and consequential applications of autonomous software agents Design of effective trading strategies requires thorough understanding of how market mechanisms operate and appreciation of strategic issues that commonly manifest in trading scenarios Drawing on research in auction theory and artificial intelligence this book presents core principles of strategic reasoning that apply to market situations The author illustrates trading strategy choices through examples of concrete market environments such as eBay as well as abstract market models defined by configurations of auctions and traders Techniques for addressing these choices constitute essential building blocks for the design of trading strategies for rich market applications The lecture assumes no prior background in game theory or auction theory or artificial intelligence Table of Contents Introduction Example Bidding on eBay Auction Fundamentals Continuous Double Auctions Interdependent Markets Conclusion   *Visual Object Recognition* Kristen Grauman,Bastian Leibe,2022-05-31 The visual recognition problem is central to computer vision research From robotics to information retrieval many desired applications demand the ability to identify and localize categories places and objects This tutorial overviews computer vision algorithms for visual object recognition and image classification We introduce primary representations and learning approaches with an emphasis on recent advances in the field The target audience consists of researchers or students working in AI robotics or vision who would like to understand what methods and representations are available for these problems This lecture summarizes what is and isn t possible to do reliably today and overviews key concepts that could be employed in systems requiring visual categorization Table of Contents Introduction Overview Recognition of Specific Objects Local Features Detection and Description Matching Local Features Geometric Verification of Matched Features Example Systems Specific Object Recognition Overview Recognition of Generic Object Categories Representations for Object Categories Generic Object Detection Finding and Scoring Candidates Learning Generic Object Category Models Example Systems Generic Object Recognition Other Considerations and Current Challenges Conclusions

Enjoying the Melody of Expression: An Psychological Symphony within **Markov Logic An Interface Layer For Artificial Intelligence Daniel Lowd**

In some sort of taken by screens and the ceaseless chatter of quick transmission, the melodic beauty and mental symphony produced by the written word often fade in to the back ground, eclipsed by the persistent sound and distractions that permeate our lives. However, nestled within the pages of **Markov Logic An Interface Layer For Artificial Intelligence Daniel Lowd** a stunning literary treasure full of natural thoughts, lies an immersive symphony waiting to be embraced. Crafted by an elegant musician of language, that captivating masterpiece conducts readers on a psychological journey, skillfully unraveling the hidden melodies and profound influence resonating within each cautiously crafted phrase. Within the depths of this moving assessment, we can examine the book is central harmonies, analyze its enthralling writing style, and surrender ourselves to the profound resonance that echoes in the depths of readers souls.

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