Reinforcement Learning By Richard S Sutton

Artificial intelligence (AI) is regarded as the science and technology for producing an intelligent machine, particularly, an intelligent computer program. Machine learning is an approach to realizing AI comprising a collection of statistical algorithms, of which deep learning is one such example. Due to the rapid development of computer technology, AI has been actively explored for a variety of academic and practical purposes in the context of financial markets. This book focuses on the broad topic of "AI and Financial Markets", and includes novel research associated with this topic. The book includes contributions on the application of machine learning, agent-based artificial market simulation, and other related skills to the analysis of various aspects of financial markets.

Rigorous treatment of the theory of deep learning from first principles, with applications to beautiful problems in the natural sciences.

The significantly expanded and updated new edition of a widely used text on reinforcement learning, one of the most active research areas in artificial intelligence. Reinforcement learning, one of the most active research areas in artificial intelligence, is a computational approach to learning whereby an agent tries to maximize the total amount of reward it receives while interacting with a complex, uncertain environment. In Reinforcement Learning, Richard Sutton and Andrew Barto provide a clear and simple account of the field's key ideas and algorithms. This second edition has been significantly expanded and updated, presenting new topics and updating coverage of other topics. Like the first edition, this second edition focuses on core online learning algorithms, with the more mathematical material set off in shaded boxes. Part I covers as much of reinforcement learning as possible without going beyond the tabular case for which exact solutions can be found. Many algorithms presented in this part are new to the second edition, including UCB, Expected Sarsa, and Double Learning. Part II extends these ideas to function approximation, with new sections on such topics as artificial neural networks and the Fourier basis, and offers expanded treatment of off-policy learning and policy-gradient methods. Part III has new chapters on reinforcement learning's relationships to psychology and neuroscience, as well as an updated case-studies chapter including AlphaGo and AlphaGo Zero, Atari game playing, and IBM Watson's wagering strategy. The final chapter discusses the future societal impacts of reinforcement learning.

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Move beyond the foundations of machine learning and game theory in cyber security to the latest research in this cutting-edge field In Game Theory and Machine Learning for Cyber Security, a team of expert security researchers delivers a collection of central research contributions from both machine learning and game theory applicable to cybersecurity. The distinguished editors have included resources that address open research questions in game theory and machine learning applied to cyber security systems and examine the strengths and limitations of current game theoretic models for cyber security. Readers will explore the vulnerabilities of traditional machine learning algorithms and how they can be mitigated in an adversarial machine learning approach. The book offers a comprehensive suite of solutions to a broad range of technical issues in applying game theory and machine learning to solve cyber security challenges. Beginning with an introduction to foundational concepts in game theory, machine learning, cyber security, and cyber deception, the editors provide readers with resources that discuss the latest in hypergames, behavioral game theory, adversarial machine learning, generative adversarial networks, and multi-agent reinforcement learning. Readers will also enjoy: A thorough introduction to game theory for cyber deception, including scalable algorithms for identifying stealthy attackers in a game theoretic framework, honeypot allocation over attack graphs, and behavioral games for cyber deception An exploration of game theory for cyber security, including actionable game-theoretic adversarial intervention detection against persistent and advanced threats Practical discussions of adversarial machine learning for cyber security, including adversarial machine learning in 5G security and machine learning-driven fault injection in cyber-physical systems In-depth examinations of generative models for cyber security Perfect for researchers, students, and experts in the fields of computer science and engineering, Game Theory and Machine Learning for Cyber Security is also an indispensable resource for industry professionals, military personnel, researchers, faculty, and students with an interest in cyber security.

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This book constitutes the refereed proceedings of the 16th Australian Conference on Artificial Intelligence, AI 2003, held in Perth, Australia in December 2003. The 87 revised full papers presented together with 4 keynote papers were carefully reviewed and selected from 179 submissions. The papers are organized in topical sections on ontologies, problem solving, knowledge discovery and data mining, expert systems, neural network applications, belief revision and theorem proving, reasoning and logic, machine learning, AI applications, neural computing, intelligent agents, computer vision, medical applications, machine learning and language, AI and business, soft computing, language understanding, and theory.

AI 2001 is the 14th in the series of Arti cial Intelligence conferences sponsored by the Canadian Society for Computational Studies of Intelligence/Soci et e - nadienne pour l' etude de l'intelligence par ordinateur. As was the case last year too, the conference is being held in conjunction with the annual conferences of two other Canadian societies, Graphics Interface (GI 2001) and Vision Int- face (VI 2001). We believe that the overall experience will be enriched by this conjunction of conferences. This year is the \silver anniversary" of the conference: the rst Canadian AI conference was held in 1976 at UBC. During its lifetime, it has attracted Canadian and international papers of high quality from a variety of AI research areas. All papers submitted to the conference received at least three indep- dent reviews. Approximately one third were accepted for plenary presentation at the conference. The best paper of the conference will be invited to appear in Computational Intelligence.

The goal of this book is to present the latest applications of machine learning, which mainly include: speech recognition, traffic and fault classification, surface quality prediction in laser machining, network security and bioinformatics, enterprise credit risk evaluation, and so on. This book will be of interest to industrial engineers and scientists as well as academics who wish to pursue machine learning. The book is intended for both graduate and postgraduate students in fields such as computer science, cybernetics, system sciences, engineering, statistics, and social sciences, and as a reference for software professionals and practitioners. The wide scope of the book provides them with a good introduction to many application researches of machine learning, and it is also the source of useful bibliographical information.

This book constitutes the refereed preceedings of the 13th European Conference on Machine Learning, ECML 2002, held in Helsinki, Finland in August 2002. The 41 revised full papers presented together with 4 invited contributions were carefully reviewed and selected from numerous submissions. Among the topics covered are computational discovery, search strategies, Classification, support vector machines, kernel methods, rule induction, linear learning, decision tree learning, boosting, collaborative learning, statistical

learning, clustering, instance-based learning, reinforcement learning, multiagent learning, multirelational learning, Markov decision processes, active learning, etc.

The NATO sponsored Advanced Study Institute 'The Biology and Tech nology of Intelligent Autonomous Agents' was an extraordinary event. For two weeks it brought together the leading proponents of the new behavior oriented approach to Artificial Intelligence in Castel Ivano near Trento. The goal of the meeting was to establish a solid scientific and technological foun dation for the field of intelligent autonomous agents with a bias towards the new methodologies and techniques that have recently been developed in Ar tificial Intelligence under the strong influence of biology. Major themes of the conference were: bottom-up AI research, artificial life, neural networks and techniques of emergent functionality. The meeting was such an extraordinary event because it not only featured very high quality lectures on autonomous agents and the various fields feeding it, but also robot laboratories which were set up by the MIT AI laboratory (with a lab led by Rodney Brooks) and the VUB AI laboratory (with labs led by Tim Smithers and Luc Steels). This way the participants could also gain practical experience and discuss in concreto what the difficulties and achievements were of different approaches. In fact, the meeting has been such a success that a follow up meeting is planned for September 1995 in Monte Verita (Switzerland). This meeting is organised by Rolf Pfeifer (University of Zurich).

An introductory text in machine learning that gives a unified treatment of methods based on statistics, pattern recognition, neural networks, artificial intelligence, signal processing, control, and data mining.

Learning to perform complex action strategies is an important problem in the fields of artificial intelligence, robotics, and machine learning. Filled with interesting new experimental results, Learning in Embedded Systems explores algorithms that learn efficiently from trial-and error experience with an external world. It is the first detailed exploration of the problem of learning action strategies in the context of designing embedded systems that adapt their behavior to a complex, changing environment; such systems include mobile robots, factory process controllers, and long-term software databases. Kaelbling investigates a rapidly expanding branch of machine learning known as reinforcement learning, including the important problems of controlled exploration of the environment, learning in highly complex environments, and learning from delayed reward. She reviews past work in this area and presents a number of significant new results. These include the intervalestimation algorithm for exploration, the use of biases to make learning more efficient in complex environments, a generate-and-test algorithm that combines symbolic and statistical processing into a flexible learning method, and some of the first reinforcement-learning experiments with a real robot.

This volume contains the papers presented at the 13th Annual Conference on Algorithmic Learning Theory (ALT 2002), which was held in Lub ? eck (Germany) during November 24–26, 2002. The main objective of the conference was to p- vide an interdisciplinary forum discussing the theoretical foundations of machine learning as well as their relevance to practical applications. The conference was colocated with the Fifth International Conference on Discovery Science (DS 2002). The volume includes 26 technical contributions which were selected by the program committee from 49 submissions. It also contains the ALT 2002 invited talks presented by Susumu Hayashi (Kobe University, Japan) on "Mathematics Based on Learning", by John Shawe-Taylor (Royal Holloway University of L- don, UK) on "On the Eigenspectrum of the Gram Matrix and Its Relationship to the Operator Eigenspectrum", and by Ian H. Witten (University of Waikato, New Zealand) on "Learning Structure from Sequences, with Applications in a Digital Library" (joint invited talk with DS 2002). Furthermore, this volume - cludes abstracts of the invited talks for DS 2002 presented by Gerhard Widmer (Austrian Research Institute for Arti?cial Intelligence, Vienna) on "In Search of the Horowitz Factor: Interim Report on a Musical Discovery Project" and by Rudolf Kruse (University of Magdeburg, Germany) on "Data Mining with Graphical Models". The complete versions of these papers are published in the DS 2002 proceedings (Lecture Notes in Arti?cial Intelligence, Vol. 2534). ALT has been awarding the E.

This book constitutes, together with its compagnion LNCS 1607, the refereed proceedings of the International Work-Conference on Artificial and Natural Neural Networks, IWANN'99, held in Alicante, Spain in June 1999. The 89 revised papers presented were carefully reviewed and selected for inclusion in the book. This volume is devoted to foundational issues of neural computation and tools for neural modeling. The papers are organized in parts on neural modeling: biophysical and structural models; plasticity phenomena: maturing, learning, and memory; and artificial intelligence and cognitive neuroscience.

This book constitutes the refereed proceedings of the 15th European Conference on Machine Learning, ECML 2004, held in Pisa, Italy, in September 2004, jointly with PKDD 2004. The 45 revised full papers and 6 revised short papers presented together with abstracts of 5 invited talks were carefully reviewed and selected from 280 papers submitted to ECML and 107 papers submitted to both, ECML and PKDD. The papers present a wealth of new results in the area and address all current issues in machine learning.

In a world where big data is the norm and near-real-time decisions are crucial, machine learning (ML) is a critical component of the data workflow. Machine learning systems can quickly crunch massive amounts of information to offer insights and make decisions in a way that matches or even surpasses human cognitive abilities. These systems use sophisticated computational and statistical tools to build models that can recognize and visualize patterns, predict outcomes, forecast values, and make recommendations. Real-World Machine Learning is a practical guide designed to teach developers the art of ML project execution. The book introduces the day-to-day practice of machine learning and prepares readers to successfully build and deploy powerful ML systems. Using the Python language and the R statistical package, it starts with core concepts like data acquisition and modeling, classification, and regression. Then it moves through the most important ML tasks, like model validation, optimization and feature engineering. It uses real-world examples that help readers anticipate and overcome common pitfalls. Along the way, they will discover scalable and online algorithms for large and streaming data sets. Advanced readers will appreciate the in-depth discussion of enhanced ML systems through advanced data exploration and pre-processing methods. Purchase of the print book includes a free eBook in PDF, Kindle, and ePub formats from Manning Publications.

Recent Advances in Reinforcement Learning addresses current research in an exciting area that is gaining a great deal of popularity in the Artificial Intelligence and Neural Network communities. Reinforcement learning has become a primary paradigm of machine learning. It applies to problems in which an agent (such as a robot, a process controller, or an information-retrieval engine) has to learn how to behave given only information about the success of its current actions. This book is a collection of important papers that address topics including the theoretical foundations of dynamic programming approaches, the role of prior knowledge, and methods for improving performance of reinforcement-learning techniques. These papers build on previous work and will form an important resource for students and researchers in the area. Recent Advances in Reinforcement Learning is an edited volume of peer-reviewed original research comprising twelve invited contributions by leading researchers. This research work has also been published as a special issue of Machine Learning (Volume 22, Numbers 1, 2 and 3).

Reliable and straightforward, this text has helped thousands of students learn to write well. Jean Wyrick's rhetorically organized STEPS TO WRITING WELL WITH ADDITIONAL READINGS is known for its student-friendly tone and the clear way it presents the basics of essay writing in an easy-to-follow progression of useful lessons and activities. Through straightforward advice and thoughtful assignments, the text gives students the practice they need to approach writing well-constructed essays with confidence. With Wyrick's helpful instruction and the book's professional samples by both well-known classic and contemporary writers, STEPS TO WRITING WELL WITH ADDITIONAL READINGS sets students on a solid path to writing success. Everything students need to begin, organize, and revise writing--from choosing a topic to developing the essay to polishing prose--is right here In the ninth edition, Wyrick updates and refines the book's successful approach, adding useful new discussions, readings, exercises, essay assignments, and visual images for analysis.

Reinforcement learning (RL) will deliver one of the biggest breakthroughs in AI over the next decade, enabling algorithms to learn from their environment to achieve arbitrary goals. This exciting development avoids constraints found in traditional machine learning (ML) algorithms. This practical book shows data science and AI professionals how to learn by reinforcementand enable a machine to learn by itself. Author Phil Winder of Winder Research covers everything from basic building blocks to state-of-the-art practices. You'll explore the current state of RL, focus on industrial applications, learnnumerous algorithms, and benefit from dedicated chapters on deploying RL solutions to production. This is no cookbook; doesn't shy away from math and expects familiarity with ML. Learn what RL is and how the algorithms help solve problems Become grounded in RL fundamentals including Markov decision processes, dynamic programming, and temporal difference learning Dive deep into a range of value and policy gradient methods Apply advanced RL solutions such as meta learning, hierarchical learning, multi-agent, and imitation learning Understand cutting-edge deep RL algorithms including Rainbow, PPO, TD3, SAC, and more Get practical examples through the accompanying website

A substantially revised fourth edition of a comprehensive textbook, including new coverage of recent advances in deep learning and neural networks. The goal of machine learning is to program computers to use example data or past experience to solve a given problem. Machine learning underlies such exciting new technologies as self-driving cars, speech recognition, and translation applications. This substantially revised fourth edition of a comprehensive, widely used machine learning textbook offers new coverage of recent advances in the field in both theory and practice, including developments in deep learning and neural networks. The book covers a broad array of topics not usually included in introductory machine learning texts, including supervised learning, Bayesian decision theory, parametric methods, semiparametric methods, nonparametric methods, multivariate analysis, hidden Markov models, reinforcement learning, kernel machines, graphical models, Bayesian estimation, and statistical testing. The fourth edition offers a new chapter on deep learning that discusses training, regularizing, and structuring deep neural networks such as convolutional and generative adversarial networks; new material in the chapter on reinforcement learning that covers the use of deep networks, the policy gradient methods, and deep reinforcement learning; new material in the chapter on multilayer perceptrons on autoencoders and the word2vec network; and discussion of a popular method of dimensionality reduction, t-SNE. New appendixes offer background material on linear algebra and optimization. End-of-chapter exercises help readers to apply concepts learned. Introduction to Machine Learning can be used in courses for advanced undergraduate and graduate students and as a reference for professionals.

This book constitutes the refereed proceedings of the 10th International Conference on Inductive Logic Programming, ILP 2000, held in London, UK in July 2000 as past of CL 2000. The 15 revised full papers presented together with an invited paper were carefully reviewed and selected from 37 submissions. The papers address all current issues in inductive logic programming and inductive learning, from foundational aspects to applications in various fields like data mining, knowledge discovery, and ILP system design.

The purpose of this book is to provide an up-to-date and systematical introduction to the principles and algorithms of machine learning. The definition of learning is broad enough to include most tasks that we commonly call "learning" tasks, as we use the word in daily life. It is also broad enough to encompass computers that improve from experience in quite straightforward ways. The book will be of interest to industrial engineers and scientists as well as academics who wish to pursue machine learning. The book is intended for both graduate and postgraduate students in fields such as computer science, cybernetics, system sciences, engineering, statistics, and social sciences, and as a reference for software professionals and practitioners. The wide scope of the book provides a good introduction to many approaches of machine learning, and it is also the source of useful bibliographical information.

Reinforcement learning is the learning of a mapping from situations to actions so as to maximize a scalar reward or reinforcement signal. The learner is not told which action to take, as in most forms of machine learning, but instead must discover which actions yield the highest reward by trying them. In the most interesting and challenging cases, actions may affect not only the immediate reward, but also the next situation, and through that all subsequent rewards. These two characteristics -- trial-and-error search and delayed reward -- are the most important distinguishing features of reinforcement learning. Reinforcement learning is both a new and a very old topic in AI. The term appears to have been coined by Minsk (1961), and independently in control theory by Walz and Fu (1965). The earliest machine learning research now viewed as directly relevant was Samuel's (1959) checker player, which used temporal-difference learning to manage delayed reward much as it is used today. Of course learning and reinforcement have been studied in psychology for almost a century, and that work has had a very strong impact on the AI/engineering work. One could in fact consider all of reinforcement learning to be simply the reverse engineering of certain psychological learning processes (e.g. operant conditioning and secondary reinforcement). Reinforcement Learning is an edited volume of original research, comprising seven invited contributions by leading researchers.

The proceedings of ECML/PKDD2003 are published in two volumes: the P- ceedings of the 14th European Conference on Machine Learning (LNAI 2837) and the Proceedings of the 7th European Conference on Principles and Practice of Knowledge Discovery in Databases (LNAI 2838). The two conferences were held on September 22–26, 2003 in Cavtat, a small tourist town in the vicinity of Dubrovnik, Croatia. As machine learning and knowledge discovery are two highly related ?elds, theco-locationofbothconferencesisbene?cialforbothresearchcommunities.In Cavtat, ECML and PKDD were co-located for the third time in a row, following the successful co-location of the two European conferences in Freiburg (2001) and Helsinki (2002). The co-location of ECML2003 and PKDD2003 resulted in a joint program for the two conferences, including paper presentations, invited talks, tutorials, and workshops. Out of 332 submitted papers,

40 were accepted for publication in the ECML2003proceedings,and40wereacceptedforpublicationinthePKDD2003 proceedings. All the submitted papers were reviewed by three referees. In ad- tion to submitted papers, the conference program consisted of four invited talks, four tutorials, seven workshops, two tutorials combined with a workshop, and a discovery challenge.

This volume contains the proceedings of the Eurpoean Conference on Machine Learning (ECML-93), continuing the tradition of the five earlier EWSLs (European Working Sessions on Learning). The aim of these conferences is to provide a platform for presenting the latest results in the area of machine learning. The ECML-93 programme included invited talks, selected papers, and the presentation of ongoing work in poster sessions. The programme was completed by several workshops on specific topics. The volume contains papers related to all these activities. The first chapter of the proceedings contains two invited papers, one by Ross Quinlan and one by Stephen Muggleton on inductive logic programming. The second chapter contains 18 scientific papers accepted for the main sessions of the conference. The third chapter contains 18 shorter position papers. The final chapter includes three overview papers related to the ECML-93 workshops.

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Neural computation arises from the capacity of nervous tissue to process information and accumulate knowledge in an intelligent manner. Conventional computational machines have encountered enormous difficulties in duplicatingsuch functionalities. This has given rise to the development of Artificial Neural Networks where computation is distributed over a great number of local processing elements with a high degree of connectivityand in which external programming is replaced with supervised and unsupervised learning. The papers presented in this volume are carefully reviewed versions of the talks delivered at the International Workshop on Artificial Neural Networks (IWANN '93) organized by the Universities of Catalonia and the Spanish Open University at Madrid and held at Barcelona, Spain, in June 1993. The 111 papers are organized in seven sections: biological perspectives, mathematical models, learning, self-organizing networks, neural software, hardware implementation, and applications (in five subsections: signal processing and pattern recognition, communications, artificial vision, control and robotics, and other applications).

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The annual conference on NIPS is the flagship conference on neural computation. It draws top academic researchers from around the world & is considered to be a showcase conference for new developments in network algorithms & architectures. This volume contains all of the papers presented at NIPS 2006.

This book presents the proceedings of the 24th European Conference on Artificial Intelligence (ECAI 2020), held in Santiago de Compostela, Spain, from 29 August to 8 September 2020. The conference was postponed from June, and much of it conducted online due to the COVID-19 restrictions. The conference is one of the principal occasions for researchers and practitioners of AI to meet and discuss the latest trends and challenges in all fields of AI and to demonstrate innovative applications and uses of advanced AI technology. The book also includes the proceedings of the 10th Conference on Prestigious Applications of Artificial Intelligence (PAIS 2020) held at the same time. A record number of more than 1,700 submissions was received for ECAI 2020, of which 1,443 were reviewed. Of these, 361 full-papers and 36 highlight papers were accepted (an acceptance rate of 25% for full-papers and 45% for highlight papers). The book is divided into three sections: ECAI full papers; ECAI highlight papers; and PAIS papers. The topics of these papers cover all aspects of AI, including Agent-based and Multi-agent Systems; Computational Intelligence; Constraints and Satisfiability; Games and Virtual Environments; Heuristic Search; Human Aspects in AI; Information Retrieval and Filtering; Knowledge Representation and Reasoning; Machine Learning; Multidisciplinary Topics and Applications; Natural Language Processing; Planning and Scheduling; Robotics; Safe, Explainable, and Trustworthy AI; Semantic Technologies; Uncertainty in AI; and Vision. The book will be of interest to all those whose work involves the use of AI technology.

A comprehensive introduction to machine learning that uses probabilistic models and inference as a unifying approach. Today's Web-enabled deluge of electronic data calls for automated methods of data analysis. Machine learning provides these, developing methods that can automatically detect patterns in data and then use the uncovered patterns to predict future data. This textbook offers a comprehensive and self-contained introduction to the field of machine learning, based on a unified, probabilistic approach. The coverage combines breadth and depth, offering necessary background material on such topics as probability, optimization, and linear algebra as well as discussion of recent developments in the field, including conditional random fields, L1 regularization, and deep learning. The book is written in an informal, accessible style, complete with pseudo-code for the most important algorithms. All topics are copiously illustrated with color images and worked examples drawn from such application domains as biology, text processing, computer vision, and robotics. Rather than providing a cookbook of different heuristic methods, the book stresses a principled model-based approach, often using the language of graphical models to specify models in a concise and intuitive way. Almost all the models described have been implemented in a MATLAB software package—PMTK (probabilistic modeling toolkit)—that is freely available online. The book is suitable for upper-level undergraduates with an introductory-level college math background and beginning graduate students.

This book constitutes the ninth official archival publication devoted to RoboCup, documenting presentations at the RoboCup 2005 International Symposium, held in Osaka, Japan, July 2005 alongside the RoboCup Competition. The book presents 34 revised full papers and 38 revised short papers together with two award-winning papers. This is a valuable source of reference and inspiration for those interested in robotics or distributed intelligence, and mandatory reading for the rapidly growing RoboCup community.

Theory, algorithms, and applications of machine learning techniques to overcome "covariate shift" non-stationarity. As the power of computing has grown over the past few decades, the field of machine learning has advanced rapidly in both theory and practice. Machine learning methods are usually based on the assumption that the data generation mechanism does not change over time. Yet real-world applications of machine learning, including image recognition, natural language processing, speech recognition, robot control, and bioinformatics, often violate this common assumption. Dealing with non-stationarity is one of modern machine learning's greatest challenges. This book focuses on a specific non-stationary environment known as covariate shift, in which the distributions of inputs (queries) change but the conditional distribution of outputs (answers) is unchanged, and presents machine learning theory, algorithms, and applications to overcome this variety of non-stationarity. After reviewing the state-of-the-art research in the field, the authors discuss topics that include learning under covariate shift, model selection,

importance estimation, and active learning. They describe such real world applications of covariate shift adaption as brain-computer interface, speaker identification, and age prediction from facial images. With this book, they aim to encourage future research in machine learning, statistics, and engineering that strives to create truly autonomous learning machines able to learn under non-stationarity.

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

This graduate-level textbook introduces fundamental concepts and methods in machine learning. It describes several important modern algorithms, provides the theoretical underpinnings of these algorithms, and illustrates key aspects for their application. The authors aim to present novel theoretical tools and concepts while giving concise proofs even for relatively advanced topics. Foundations of Machine Learning fills the need for a general textbook that also offers theoretical details and an emphasis on proofs. Certain topics that are often treated with insufficient attention are discussed in more detail here; for example, entire chapters are devoted to regression, multi-class classification, and ranking. The first three chapters lay the theoretical foundation for what follows, but each remaining chapter is mostly self-contained. The appendix offers a concise probability review, a short introduction to convex optimization, tools for concentration bounds, and several basic properties of matrices and norms used in the book.The book is intended for graduate students and researchers in machine learning, statistics, and related areas; it can be used either as a textbook or as a reference text for a research seminar.