

Table of Contents

Chapter I Artificial Intelligence

1. Introduction

- What Is AI?
- The Foundations of Artificial Intelligence
- The History of Artificial Intelligence
- The State of the Art
- Risks and Benefits of AI

Summary

Bibliographical and Historical Notes

2. Intelligent Agents

- Agents and Environments
- Good Behavior: The Concept of Rationality
- The Nature of Environments
- The Structure of Agents

Summary

Bibliographical and Historical Notes

Chapter II Problem Solving

3. Solving Problems by Searching

- Problem-Solving Agents
- Example Problems
- Search Algorithms
- Uninformed Search Strategies
- Informed (Heuristic) Search Strategies
- Heuristic Functions

Summary

Bibliographical and Historical Notes

4. Search in Complex Environments

- Local Search and Optimization Problems
- Local Search in Continuous Spaces
- Search with Nondeterministic Actions
- Search in Partially Observable Environments
- Online Search Agents and Unknown Environments

Summary

Bibliographical and Historical Notes

5. **Constraint Satisfaction Problems**
 - Defining Constraint Satisfaction Problems
 - Constraint Propagation: Inference in CSPs
 - Backtracking Search for CSPs
 - Local Search for CSPs
 - The Structure of Problems

Summary

Bibliographical and Historical Notes

6. **Adversarial Search and Games**
 - Game Theory
 - Optimal Decisions in Games
 - Heuristic Alpha--Beta Tree Search
 - Monte Carlo Tree Search
 - Stochastic Games
 - Partially Observable Games
 - Limitations of Game Search Algorithms

Summary

Bibliographical and Historical Notes

Chapter III Knowledge, Reasoning and Planning

7. **Logical Agents**
 - Knowledge-Based Agents
 - The Wumpus World
 - Logic
 - Propositional Logic: A Very Simple Logic
 - Propositional Theorem Proving
 - Effective Propositional Model Checking
 - Agents Based on Propositional Logic

Summary

Bibliographical and Historical Notes

8. **First-Order Logic**
 - Representation Revisited
 - Syntax and Semantics of First-Order Logic
 - Using First-Order Logic
 - Knowledge Engineering in First-Order Logic

Summary

Bibliographical and Historical Notes

9. Inference in First-Order Logic

- Propositional vs. First-Order Inference
- Unification and First-Order Inference
- Forward Chaining
- Backward Chaining
- Resolution

Summary

Bibliographical and Historical Notes

10. Knowledge Representation

- Ontological Engineering
- Categories and Objects
- Events
- Mental Objects and Modal Logic
- for Categories
- Reasoning with Default Information

Summary

Bibliographical and Historical Notes

11. Automated Planning

- Definition of Classical Planning
- Algorithms for Classical Planning
- Heuristics for Planning
- Hierarchical Planning
- Planning and Acting in Nondeterministic Domains
- Time, Schedules, and Resources
- Analysis of Planning Approaches

Summary

Bibliographical and Historical Notes

Chapter IV Uncertain Knowledge and Reasoning

12. Quantifying Uncertainty

- Acting under Uncertainty
- Basic Probability Notation
- Inference Using Full Joint Distributions
- Independence 12.5 Bayes' Rule and Its Use
- Naive Bayes Models

- The Wumpus World Revisited

Summary

Bibliographical and Historical Notes

13. Probabilistic Reasoning

- Representing Knowledge in an Uncertain Domain
- The Semantics of Bayesian Networks
- Exact Inference in Bayesian Networks
- Approximate Inference for Bayesian Networks
- Causal Networks

Summary

Bibliographical and Historical Notes

14. Probabilistic Reasoning over Time

- Time and Uncertainty
- Inference in Temporal Models
- Hidden Markov Models
- Kalman Filters
- Dynamic Bayesian Networks

Summary

Bibliographical and Historical Notes

15. Making Simple Decisions

- Combining Beliefs and Desires under Uncertainty
- The Basis of Utility Theory
- Utility Functions
- Multiattribute Utility Functions
- Decision Networks
- The Value of Information
- Unknown Preferences

Summary

Bibliographical and Historical Notes

16. Making Complex Decisions

- Sequential Decision Problems
- Algorithms for MDPs
- Bandit Problems
- Partially Observable MDPs
- Algorithms for Solving POMDPs

Summary

Bibliographical and Historical Notes

17. Multiagent Decision Making

- Properties of Multiagent Environments
- Non-Cooperative Game Theory
- Cooperative Game Theory
- Making Collective Decisions

Summary

Bibliographical and Historical Notes

18. Probabilistic Programming

- Relational Probability Models
- Open-Universe Probability Models
- Keeping Track of a Complex World
- Programs as Probability Models

Summary

Bibliographical and Historical Notes

Chapter V Machine Learning

19. Learning from Examples

- Forms of Learning
- Supervised Learning .
- Learning Decision Trees .
- Model Selection and Optimization
- The Theory of Learning
- Linear Regression and Classification
- Nonparametric Models
- Ensemble Learning
- Developing Machine Learning System

Summary

Bibliographical and Historical Notes

20. Knowledge in Learning

- A Logical Formulation of Learning
- Knowledge in Learning
- Explanation-Based Learning
- Learning Using Relevance Information
- Inductive Logic Programming

Summary

Bibliographical and Historical Notes

21. Learning Probabilistic Models

- Statistical Learning
- Learning with Complete Data
- Learning with Hidden Variables: The EM Algorithm

Summary

Bibliographical and Historical Notes

22. Deep Learning

- Simple Feedforward Networks
- Computation Graphs for Deep Learning
- Convolutional Networks
- Learning Algorithms
- Generalization
- Recurrent Neural Networks
- Unsupervised Learning and Transfer Learning
- Applications

Summary

Bibliographical and Historical Notes

23. Reinforcement Learning

- Learning from Rewards
- Passive Reinforcement Learning
- Active Reinforcement Learning
- Generalization in Reinforcement Learning
- Policy Search
- Apprenticeship and Inverse Reinforcement Learning
- Applications of Reinforcement Learning

Summary

Bibliographical and Historical Notes

Chapter VI Communicating, perceiving, and acting

24. Natural Language Processing

- Language Models
- Grammar
- Parsing
- Augmented Grammars
- Complications of Real Natural Language

- Natural Language Tasks

Summary

Bibliographical and Historical Notes

25. Deep Learning for Natural Language Processing

- Word Embeddings
- Recurrent Neural Networks for NLP
- Sequence-to-Sequence Models
- The Transformer Architecture
- Pretraining and Transfer Learning
- State of the art

Summary

Bibliographical and Historical Notes

26. Robotics

- Robots
- Robot Hardware
- What kind of problem is robotics solving?
- Robotic Perception
- Planning and Control
- Planning Uncertain Movements
- Reinforcement Learning in Robotics
- Humans and Robots
- Alternative Robotic Frameworks
- Application Domains

Summary

Bibliographical and Historical Notes

27. Computer Vision

- Introduction
- Image Formation
- Simple Image Features
- Classifying Images
- Detecting Objects
- The 3D World
- Using Computer Vision

Summary

Bibliographical and Historical Notes

Chapter VII Conclusions

28. Philosophy, Ethics, and Safety of AI

- The Limits of AI
- Can Machines Really Think?
- The Ethics of AI

Summary

Bibliographical and Historical Notes

29. The Future of AI

- AI Components
- AI Architectures

A Mathematical Background

- A.1 Complexity Analysis and OO Notation
- A.2 Vectors, Matrices, and Linear Algebra
- A.3 Probability Distributions
- Bibliographical and Historical Notes

B Notes on Languages and Algorithms

- B.1 Defining Languages with Backus-Naur Form (BNF)
- B.2 Describing Algorithms with Pseudocode
- B.3 Online Supplemental Material