

Machine Learning Book Structure

Chapters and Sections

Chapter 1: Introduction to Machine Learning

- What is Machine Learning?
- Types of Learning
- ML Workflow
- Mathematical Preliminaries

Chapter 2: Clustering

- Clustering Overview
- K-Means Clustering
- Evaluation Metrics & GMM

Chapter 3: Probabilistic Modeling and Density Estimation

- Probability Review
- Probabilistic Modeling
- Density Estimation
- Clustering via Probabilistic Models

Chapter 4: Principal Component Analysis (PCA)

- Introduction to Dimensionality Reduction
- PCA Basics
- PCA Mathematics
- PCA Algorithm
- PCA in Practice
- Applications and Limitations

Chapter 5: Linear Regression and Classification

- Linear Regression
- Linear Classification
- Geometric Interpretation
- Evaluation Metrics

Chapter 6: Gradient Descent and Classification with Confidence

- Gradient Descent Optimization
- Confidence in Classification
- Calibration and Decision Boundaries

- Practical Considerations

Chapter 7: Support Vector Machine (SVM)

- Linear Classifiers Recap
- Maximum Margin Classifier
- Dual Formulation
- Kernel Trick
- Soft-Margin SVM
- SVM in Practice

Chapter 8: Neural Networks

- Biological and Historical Motivation
- Perceptron Model
- Multilayer Perceptrons (MLPs)
- Forward Propagation
- Training Neural Networks
- Design Considerations
- Backpropagation Algorithm
- Training Deep Networks
- Optimizers
- Batch Normalization
- Expressivity and Overfitting
- Generalization in Neural Networks

Chapter 9: Generalization in Machine Learning

- Definition and Importance
- Underfitting vs. Overfitting
- Bias–Variance Tradeoff
- Capacity, Complexity, and Model Selection
- Regularization Techniques
- Validation Methods

Chapter 10: Convolutional Neural Networks (CNNs)

- Motivation and Use in Vision Tasks
- Convolution Operation
- Filters and Feature Maps
- Padding and Stride
- Pooling Layers
- ReLU and Activation Maps
- Architecture of Typical CNNs
- Training CNNs

Chapter 11: Sequence Data Analysis

- Challenges with Temporal or Sequential Data

- Sequence Modeling Tasks
- Recurrent Neural Networks (RNNs)
- Advanced Sequence Models

Chapter 12: Data Generation

- Synthetic vs. Real-World Data
- Generative Models Overview
- Gaussian Mixture Models (GMMs)
- Variational Autoencoders (VAEs)
- Generative Adversarial Networks (GANs)
- Sampling Methods

Chapter 13: Introduction to Reinforcement Learning (RL)

- Agent-Environment Interaction
- Markov Decision Processes (MDPs)
- Reward Signal and Return
- Policy, Value Function, and Q-Function
- Exploration vs. Exploitation Trade-off
- Applications of RL
- Basic RL Algorithms