

Contents

Foreword	xv
Preface	xvii
Who This Book is For	xvii
How to Use This Book	xviii
Should You Buy This Book?	xviii
1 Introduction	1
1.1 What is Machine Learning	1
1.2 Types of Learning	1
1.2.1 Supervised Learning	1
1.2.2 Unsupervised Learning	2
1.2.3 Semi-Supervised Learning	2
1.2.4 Reinforcement Learning	3
1.3 How Supervised Learning Works	3
1.4 Why the Model Works on New Data	7
2 Notation and Definitions	9
2.1 Notation	9
2.1.1 Data Structures	9
2.1.2 Capital Sigma Notation	10
2.1.3 Capital Pi Notation	11

2.1.4	Operations on Sets	11
2.1.5	Operations on Vectors	11
2.1.6	Functions	12
2.1.7	Max and Arg Max	13
2.1.8	Assignment Operator	14
2.1.9	Derivative and Gradient	14
2.2	Random Variable	15
2.3	Unbiased Estimators	17
2.4	Bayes' Rule	17
2.5	Parameter Estimation	17
2.6	Parameters vs. Hyperparameters	18
2.7	Classification vs. Regression	19
2.8	Model-Based vs. Instance-Based Learning	19
2.9	Shallow vs. Deep Learning	20
3	Fundamental Algorithms	21
3.1	Linear Regression	21
3.1.1	Problem Statement	21
3.1.2	Solution	23
3.2	Logistic Regression	25
3.2.1	Problem Statement	25
3.2.2	Solution	26
3.3	Decision Tree Learning	27
3.3.1	Problem Statement	27
3.3.2	Solution	28
3.4	Support Vector Machine	30
3.4.1	Dealing with Noise	31
3.4.2	Dealing with Inherent Non-Linearity	32
3.5	k-Nearest Neighbors	34

4	Anatomy of a Learning Algorithm	35
4.1	Building Blocks of a Learning Algorithm	35
4.2	Gradient Descent	36
4.3	How Machine Learning Engineers Work	41
4.4	Learning Algorithms' Particularities	41
5	Basic Practice	43
5.1	Feature Engineering	43
5.1.1	One-Hot Encoding	44
5.1.2	Binning	44
5.1.3	Normalization	45
5.1.4	Standardization	45
5.1.5	Dealing with Missing Features	46
5.1.6	Data Imputation Techniques	47
5.2	Learning Algorithm Selection	47
5.3	Three Sets	49
5.4	Underfitting and Overfitting	51
5.5	Regularization	52
5.6	Model Performance Assessment	54
5.6.1	Confusion Matrix	55
5.6.2	Precision/Recall	55
5.6.3	Accuracy	56
5.6.4	Cost-Sensitive Accuracy	57
5.6.5	Area under the ROC Curve (AUC)	58
5.7	Hyperparameter Tuning	58
5.7.1	Cross-Validation	60

6	Neural Networks and Deep Learning	61
6.1	Neural Networks	61
6.1.1	Multilayer Perceptron Example	62
6.1.2	Feed-Forward Neural Network Architecture	64
6.2	Deep Learning	65
6.2.1	Convolutional Neural Network	65
6.2.2	Recurrent Neural Network	72
7	Problems and Solutions	77
7.1	Kernel Regression	77
7.2	Multiclass Classification	78
7.3	One-Class Classification	79
7.4	Multi-Label Classification	81
7.5	Ensemble Learning	83
7.5.1	Boosting and Bagging	83
7.5.2	Random Forest	84
7.5.3	Gradient Boosting	85
7.6	Learning to Label Sequences	87
7.7	Sequence-to-Sequence Learning	89
7.8	Active Learning	90
7.9	Semi-Supervised Learning	91
7.10	One-Shot Learning	94
7.11	Zero-Shot Learning	95
8	Advanced Practice	97
8.1	Handling Imbalanced Datasets	97
8.2	Combining Models	99
8.3	Training Neural Networks	99
8.4	Advanced Regularization	100
8.5	Handling Multiple Inputs	101

8.6	Handling Multiple Outputs	102
8.7	Transfer Learning	102
8.8	Algorithmic Efficiency	104
9	Unsupervised Learning	107
9.1	Density Estimation	107
9.2	Clustering	109
9.2.1	K-Means	110
9.2.2	DBSCAN and HDBSCAN	111
9.2.3	Determining the Number of Clusters	112
9.2.4	Other Clustering Algorithms	114
9.3	Dimensionality Reduction	118
9.3.1	Principal Component Analysis	118
9.3.2	UMAP	119
10	Other Forms of Learning	121
10.1	Metric Learning	121
10.2	Learning to Rank	123
10.3	Learning to Recommend	125
10.3.1	Factorization Machines	126
10.3.2	Denoising Autoencoders	128
10.4	Self-Supervised Learning: Word Embeddings	128
10.5	Outlier Detection	130
11	Conclusion	131
11.1	What Wasn't Covered	131
11.1.1	Topic Modeling	131
11.1.2	Gaussian Processes	132
11.1.3	Generalized Linear Models	132
11.1.4	Probabilistic Graphical Models	132
11.1.5	Markov Chain Monte Carlo	132

11.1.6 Generative Adversarial Networks	133
11.1.7 Genetic Algorithms	133
11.1.8 Reinforcement Learning	134
11.2 Acknowledgements	134
11.3 What to Read Next	135
Index	137