

I Probabilistic Models

Review of Basic Probability

0.1	Discrete Probability
0.2	Conditional Probability, Bayes' Rule, and Independence
0.3	Random Variables on Discrete Probability Spaces
0.4	Discrete Distributions I
0.5	Discrete Distributions II
0.6	Continuous Random Variables
	Exercises

More Probability

1.1	Modes of Convergence
1.2	Moments and Characteristic Functions
1.3	Important Inequalities
1.4	The Central Limit Theorem
1.5	Functions (Transformations) of Random Variables
1.6	Conditioning of Random Variables
1.7	Information and Entropy

Markov Processes

2.1	Markov Processes
	Exercises

II Basic Statistical Modeling

Classical Inference

3.1	Nonparametric Estimation: CDFs
3.2	Nonparametric Estimation: Histograms and KDE

3.3	Parametric Estimation
3.4	*Key Properties of the MLE and Method of Moments
3.5	Fisher Information
3.6	Bootstrap Methods
3.7	Hypothesis Testing
3.8	Bayesian Statistics I
3.9	Bayesian Statistics II: Priors and Model Selection
3.10	Classical Sampling Methods

Regression

4.1	Linear Regression and GLMs
4.2	Linear Regression
4.3	Logistic Regression
4.4	Model Selection
4.5	Regularization
	Exercises

III Adaptive Methods

Graphical Models

5.1	Graphical Models
5.2	Latent Variable Models and Expectation Maximization
5.3	Mixture Models
5.4	Discrete Hidden Markov Models
5.5	CDHMMs
5.6	MCMC: Metropolis-Hastings
5.7	MCMC: Gibbs
5.8	LDA
	Exercises

Estimation in State-Space Models

6.1	State-Space Modeling
6.2	Estimating State Variables
6.3	Recursive Least Squares
6.4	Kalman Filtering I
6.5	Kalman Filtering II
6.6	Time Series Models
6.7	Training ARMA Models
6.8	Forecasting ARMA Models
	Exercises

IV Interlude

Review of Multivariate Calculus

7.1	Gradient and Hessian and Chain Rule
7.2	Matrix Derivatives

Review of Optimization

8.1 Stochastic Gradient Descent

8.2 Second-order Methods

8.3 Duality in convex optimization

V Machine Learning

ML basics

9.1 Fundamental Concepts

Exercises

Unsupervised Methods

10.1 Linear Dimensionality Reduction

10.2 Randomized PCA

10.3 Nonnegative Matrix Factorization

10.4 Clustering

10.5 The Johnson–Lindenstrauss Theorem

10.6 Embeddings

10.7 Word Representations

10.8 Compressed Sensing

Exercises

Linear Models

11.1 Binary Classification

11.2 Logistic and Softmax Regression

11.3 Algorithms for Logistic Regression

11.4 Maximum Entropy Classifiers

11.5 Hard Margin Support Vector Machines

11.6 Soft Margin Support Vector Machines

11.7 Kernels and Their Applications

Exercises

Decision Trees

12.1 Classification Trees

12.2 Regression Trees

12.3 Ensembles: Condorcet’s Theorem

12.4 Random Forests

12.5 Gradient Boosted Trees

12.6 Differentiable Trees

12.7 Convergence and Expressiveness of Trees

Exercises

Neural Networks

13.1 Basic Neural Network Structure

13.2 Back Propagation and Automatic Differentiation

13.3 Regularization Methods

Exercises

Deep Learning

14.1 Convolutional Neural Networks

14.2 Residual Networks

14.3 Long and Short Term Memory Networks

14.4 Gated Rectified Units

14.5 Sequence to Sequence

VI Data Generation, Online Learning, and Reinforcement Learning

Data Augmentation and Generation

15.1 Augmentation

15.2 Generation by White-box Models

15.3 Generative Adversarial Networks

Reinforcement Learning

16.1 Review of MDPs

16.2 Q-learning

16.3 Deep Reinforcement Learning