PART I INTRODUCTION

1 Introduction 3
  1.1 Overview of Recommender Systems for Web Applications 4
  1.2 A Simple Scoring Model: Most-Popular Recommendation 10
  Exercises 14

2 Classical Methods 15
  2.1 Item Characterization 16
  2.2 User Characterization 23
  2.3 Feature-Based Methods 25
  2.4 Collaborative Filtering 31
  2.5 Hybrid Methods 36
  2.6 Summary 37
  Exercises 38

3 Explore-Exploit for Recommender Problems 39
  3.1 Introduction to the Explore-Exploit Trade-off 40
  3.2 Multiarmed Bandit Problem 41
  3.3 Explore-Exploit in Recommender Systems 48
  3.4 Explore-Exploit with Data Sparsity 50
  3.5 Summary 54
  Exercise 54
## Table of Contents

### 4 Evaluation Methods 55
- 4.1 Traditional Offline Evaluation 56
- 4.2 Online Bucket Tests 66
- 4.3 Offline Simulation 70
- 4.4 Offline Replay 73
- 4.5 Summary 77
- Exercise 78

### PART II COMMON PROBLEM SETTINGS

#### 5 Problem Settings and System Architecture 81
- 5.1 Problem Settings 81
- 5.2 System Architecture 89

#### 6 Most-Popular Recommendation 94
- 6.1 Example Application: Yahoo! Today Module 95
- 6.2 Problem Definition 96
- 6.3 Bayesian Solution 98
- 6.4 Non-Bayesian Solutions 107
- 6.5 Empirical Evaluation 109
- 6.6 Large Content Pools 117
- 6.7 Summary 118
- Exercises 119

#### 7 Personalization through Feature-Based Regression 120
- 7.1 Fast Online Bilinear Factor Model 122
- 7.2 Offline Training 126
- 7.3 Online Learning 131
- 7.4 Illustration on Yahoo! Data Sets 134
- 7.5 Summary 141
- Exercise 141

#### 8 Personalization through Factor Models 142
- 8.1 Regression-Based Latent Factor Model (RLFM) 142
- 8.2 Fitting Algorithms 150
- 8.3 Illustration of Cold Start 164
- 8.4 Large-Scale Recommendation of Time-Sensitive Items 167
- 8.5 Illustration of Large-Scale Problems 172
- 8.6 Summary 182
- Exercise 182
# Table of Contents

## PART III  ADVANCED TOPICS

9  **Factorization through Latent Dirichlet Allocation**

9.1 Introduction  
9.2 Model  
9.3 Training and Prediction  
9.4 Experiments  
9.5 Related Work  
9.6 Summary

10  **Context-Dependent Recommendation**

10.1 Tensor Factorization Models  
10.2 Hierarchical Shrinkage  
10.3 Multifaceted News Article Recommendation  
10.4 Related-Item Recommendation  
10.5 Summary

11  **Multiobjective Optimization**

11.1 Application Setting  
11.2 Segmented Approach  
11.3 Personalized Approach  
11.4 Approximation Methods  
11.5 Experiments  
11.6 Related Work  
11.7 Summary

*Endnotes*  
*References*  
*Index*