Contents

Preface xiii

1. General Introduction 1
   1.1. Introduction, 1
   1.2. Basic Notation, 4
   1.3. Allocation Rules, 6
   1.4. Decision-Theoretic Approach, 7
   1.5. Unavailability of Group-Prior Probabilities, 9
   1.6. Training Data, 11
   1.7. Sample-Based Allocation Rules, 12
   1.8. Parametric Allocation Rules, 13
   1.9. Assessment of Model Fit, 16
   1.10. Error Rates of Allocation Rules, 17
   1.11. Posterior Probabilities of Group Membership, 21
   1.12. Distances Between Groups, 22

2. Likelihood-Based Approaches to Discrimination 27
   2.1. Maximum Likelihood Estimation of Group Parameters, 27
   2.2. A Bayesian Approach, 29
   2.3. Estimation of Group Proportions, 31
   2.4. Estimating Disease Prevalence, 33
   2.5. Misclassified Training Data, 35
   2.6. Partially Classified Training Data, 37
   2.7. Maximum Likelihood Estimation for Partial Classification, 39
CONTENTS

2.8. Maximum Likelihood Estimation for Partial Nonrandom Classification, 43
2.9. Classification Likelihood Approach, 45
2.10. Absence of Classified Data, 46
2.11. Group-Conditional Mixture Densities, 50

3. Discrimination via Normal Models

3.1. Introduction, 52
3.2. Heteroscedastic Normal Model, 52
3.3. Homoscedastic Normal Model, 59
3.4. Some Other Normal-Theory Based Rules, 65
3.5. Predictive Discrimination, 67
3.6. Covariance-Adjusted Discrimination, 74
3.7. Discrimination with Repeated Measurements, 78
3.8. Partially Classified Data, 86
3.9. Linear Projections of Homoscedastic Feature Data, 87
3.10. Linear Projections of Heteroscedastic Feature Data, 96

4. Distributional Results for Discrimination via Normal Models

4.1. Introduction, 101
4.2. Distribution of Sample NLDF ($W$-Statistic), 101
4.3. Moments of Conditional Error Rates of Sample NLDR, 107
4.4. Distributions of Conditional Error Rates of Sample NLDR, 112
4.5. Constrained Allocation with the Sample NLDR, 118
4.6. Distributional Results for Quadratic Discrimination, 122

5. Some Practical Aspects and Variants of Normal Theory-Based Discriminant Rules

5.1. Introduction, 129
5.2. Regularization in Quadratic Discrimination, 130
5.3. Linear Versus Quadratic Normal-Based Discriminant Analysis, 132
5.4. Some Models for Variants of the Sample NQDR, 137
5.5. Regularized Discriminant Analysis (RDA), 144
5.6. Robustness of NLDR and NQDR, 152
5.7. Robust Estimation of Group Parameters, 161
6. Data Analytic Considerations with Normal Theory-Based Discriminant Analysis 168
   6.1. Introduction, 168
   6.2. Assessment of Normality and Homoscedasticity, 169
   6.3. Data-Based Transformations of Feature Data, 178
   6.4. Typicality of a Feature Vector, 181
   6.5. Sample Canonical Variates, 185
   6.6. Some Other Methods of Dimension Reduction to Reveal Group Structure, 196
   6.7. Example: Detection of Hemophilia A Carriers, 201
   6.8. Example: Statistical Diagnosis of Diabetes, 206
   6.9. Example: Testing for Existence of Subspecies in Fisher's Iris Data, 211

7. Parametric Discrimination via Nonnormal Models 216
   7.1. Introduction, 216
   7.2. Discrete Feature Data, 216
   7.3. Parametric Formulation for Discrete Feature Data, 218
   7.4. Location Model for Mixed Features, 220
   7.5. Error Rates of Location Model-Based Rules, 229
   7.6. Adjustments to Sample NLDR for Mixed Feature Data, 232
   7.7. Some Nonnormal Models for Continuous Feature Data, 238
   7.8. Case Study of Renal Venous Renin in Hypertension, 243
   7.9. Example: Discrimination Between Depositional Environments, 249

8. Logistic Discrimination 255
   8.1. Introduction, 255
   8.2. Maximum Likelihood Estimation of Logistic Regression Coefficients, 259
   8.3. Bias Correction of MLE for \( g = 2 \) Groups, 266
   8.4. Assessing the Fit and Performance of Logistic Model, 270
   8.5. Logistic Versus Normal-Based Linear Discriminant Analysis, 276
   8.6. Example: Differential Diagnosis of Some Liver Diseases, 279
9. Nonparametric Discrimination

9.1. Introduction, 283
9.2. Multinomial-Based Discrimination, 284
9.4. Selection of Smoothing Parameters in Kernel Estimates of Group-Conditional Densities, 300
9.5. Alternatives to Fixed Kernel Density Estimates, 308
9.6. Comparative Performance of Kernel-Based Discriminant Rules, 312
9.7. Nearest Neighbor Rules, 319
9.8. Tree-Structured Allocation Rules, 323
9.9. Some Other Nonparametric Discriminant Procedures, 332

10. Estimation of Error Rates

10.1. Introduction, 337
10.2. Some Nonparametric Error-Rate Estimators, 339
10.3. The Bootstrap, 346
10.4. Variants of the Bootstrap, 353
10.5. Smoothing of the Apparent Error Rate, 360
10.6. Parametric Error-Rate Estimators, 366
10.7. Confidence Intervals, 370
10.8. Some Other Topics in Error-Rate Estimation, 373

11. Assessing the Reliability of the Estimated Posterior Probabilities of Group Membership

11.1. Introduction, 378
11.2. Distribution of Sample Posterior Probabilities, 379
11.3. Further Approaches to Interval Estimation of Posterior Probabilities of Group Membership, 384

12. Selection of Feature Variables in Discriminant Analysis

12.1. Introduction, 389
12.2. Test for No Additional Information, 392
12.3. Some Selection Procedures, 396
12.4. Error-Rate-Based Procedures, 400
12.5. The F-Test and Error-Rate-Based Variable Selections, 406
12.6. Assessment of the Allocatory Capacity of the Selected Feature Variables, 410

13. Statistical Image Analysis 413

13.1. Introduction, 413
13.2. Markov Random Fields, 417
13.3. Noncontextual Methods of Segmentation, 421
13.4. Smoothing Methods, 422
13.5. Individual Contextual Allocation of Pixels, 425
13.6. ICM Algorithm, 428
13.7. Global Maximization of the Posterior Distribution of the Image, 435
13.8. Incomplete-Data Formulation of Image Segmentation, 438
13.9. Correlated Training Data, 443

References 447

Author Index 507

Subject Index 519