# **Contents**

Chapter I	Intro	oduction I	
	1.1	What Motivated Data Mining? Why Is It Important?	
	1.2	So, What Is Data Mining? 5	
	1.3	Data Mining—On What Kind of Data? 10	
		<ul> <li>1.3.1 Relational Databases 10</li> <li>1.3.2 Data Warehouses 12</li> <li>1.3.3 Transactional Databases 15</li> <li>1.3.4 Advanced Database Systems and Advanced Database Applications</li> </ul>	16
	1.4	Data Mining Functionalities—What Kinds of Patterns Can Be	
		Mined? 21	
		<ul> <li>I.4.1 Concept/Class Description: Characterization and Discrimination 21</li> <li>I.4.2 Association Analysis 23</li> <li>I.4.3 Classification and Prediction 24</li> <li>I.4.4 Cluster Analysis 25</li> <li>I.4.5 Outlier Analysis 25</li> <li>I.4.6 Evolution Analysis 26</li> </ul>	
	1.5	Are All of the Patterns Interesting? 27	
	1.6	Classification of Data Mining Systems 28	
	1.7	Major Issues in Data Mining 30	
	1.8	Summary 33	
		Exercises 34	
		Bibliographic Notes 35	
Chapter 2	Data	Warehouse and OLAP Technology for Data Mining 39	
	2.1	What Is a Data Warehouse? 39	
		2.1.1 Differences between Operational Database Systems and Data Warehouses 42	
		2.1.2 But, Why Have a Separate Data Warehouse? 44	κi

Foreword vii Preface xix

	2.2	A Multidimensional Data Model 44
		2.2.1 From Tables and Spreadsheets to Data Cubes 45
		2.2.2 Stars, Snowflakes, and Fact Constellations: Schemas for Multidimensiona Databases 48
		Databases 48 2.2.3 Examples for Defining Star, Snowflake, and Fact Constellation
		Schemas 52
		2.2.4 Measures: Their Categorization and Computation 54
		2.2.5 Introducing Concept Hierarchies 56
		<ul><li>2.2.6 OLAP Operations in the Multidimensional Data Model 58</li><li>2.2.7 A Starnet Query Model for Querying Multidimensional Databases 61</li></ul>
	2.3	Data Warehouse Architecture 62
	2.5	2.3.1 Steps for the Design and Construction of Data Warehouses 63
		2.3.2 A Three-Tier Data Warehouse Architecture 65
		2.3.3 Types of OLAP Servers: ROLAP versus MOLAP versus HOLAP 69
	2.4	Data Warehouse Implementation 71
		2.4.1 Efficient Computation of Data Cubes 71
		<ul><li>2.4.2 Indexing OLAP Data 79</li><li>2.4.3 Efficient Processing of OLAP Queries 81</li></ul>
		2.4.4 Metadata Repository 83
		2.4.5 Data Warehouse Back-End Tools and Utilities 84
	2.5	Further Development of Data Cube Technology 85
		2.5.1 Discovery-Driven Exploration of Data Cubes 85
		2.5.2 Complex Aggregation at Multiple Granularities: Multifeature Cubes 89
	27	2.5.3 Other Developments 92
	2.6	From Data Warehousing to Data Mining 93
		<ul><li>2.6.1 Data Warehouse Usage 93</li><li>2.6.2 From On-Line Analytical Processing to On-Line Analytical Mining 95</li></ul>
	2.7	Summary 98
		Exercises 99
		Bibliographic Notes 103
		• .
<b>ว</b>	D-4-	D
J	3.1	Preprocessing 105
	3.1	Why Preprocess the Data? 105 Data Cleaning 109
	٥.٨	<b>Data Cleaning</b> 109 3.2.1 Missing Values 109
		3.2.2 Noisy Data 110
		3.2.3 Inconsistent Data 112
	3.3	Data Integration and Transformation 112

3.3.1 Data Integration 112
3.3.2 Data Transformation 114

Chapter

		<ul><li>3.4.1 Data Cube Aggregation 117</li><li>3.4.2 Dimensionality Reduction 119</li><li>3.4.3 Data Compression 121</li><li>3.4.4 Numerosity Reduction 124</li></ul>
	3.5	Discretization and Concept Hierarchy Generation 130  3.5.1 Discretization and Concept Hierarchy Generation for Numeric Data 132
	3.6	3.5.2 Concept Hierarchy Generation for Categorical Data 138  Summary 140  Exercises 141  Bibliographic Notes 142
Chapter 4		Mining Primitives, Languages, and System nitectures 145
	4.1	Data Mining Primitives: What Defines a Data Mining Task? 146 4.1.1 Task-Relevant Data 148 4.1.2 The Kind of Knowledge to be Mined 150 4.1.3 Background Knowledge: Concept Hierarchies 151 4.1.4 Interestingness Measures 155 4.1.5 Presentation and Visualization of Discovered Patterns 157
	4.2	<ul> <li>A Data Mining Query Language 159</li> <li>4.2.1 Syntax for Task-Relevant Data Specification 160</li> <li>4.2.2 Syntax for Specifying the Kind of Knowledge to be Mined 162</li> <li>4.2.3 Syntax for Concept Hierarchy Specification 165</li> <li>4.2.4 Syntax for Interestingness Measure Specification 166</li> <li>4.2.5 Syntax for Pattern Presentation and Visualization Specification 167</li> <li>4.2.6 Putting It All Together—An Example of a DMQL Query 167</li> <li>4.2.7 Other Data Mining Languages and the Standardization of Data Mining Primitives 169</li> </ul>
•	4.3 4.4 4.5	Designing Graphical User Interfaces Based on a Data Mining Query Language 170 Architectures of Data Mining Systems 171 Summary 174 Exercises 174 Bibliographic Notes 176
Chapter 5	<b>Conc</b> 5.1 5.2	cept Description: Characterization and Comparison 179 What Is Concept Description? 179 Data Generalization and Summarization-Based Characterization 181

3.4

Data Reduction 116

		<ul><li>5.2.1 Attribute-Oriented Induction 182</li><li>5.2.2 Efficient Implementation of Attribute-Oriented Induction 187</li><li>5.2.3 Presentation of the Derived Generalization 190</li></ul>
	5.3	Analytical Characterization: Analysis of Attribute Relevance 194
		<ul><li>5.3.1 Why Perform Attribute Relevance Analysis? 195</li><li>5.3.2 Methods of Attribute Rélevance Analysis 196</li><li>5.3.3 Analytical Characterization: An Example 198</li></ul>
	5.4	Mining Class Comparisons: Discriminating between Different Classes 200
		<ul> <li>5.4.1 Class Comparison Methods and Implementations 201</li> <li>5.4.2 Presentation of Class Comparison Descriptions 204</li> <li>5.4.3 Class Description: Presentation of Both Characterization and Comparison 206</li> </ul>
	5.5	Mining Descriptive Statistical Measures in Large Databases 208
		5.5.1 Measuring the Central Tendency 209
		5.5.2 Measuring the Dispersion of Data 210
		5.5.3 Graph Displays of Basic Statistical Class Descriptions 213
	5.6	Discussion 217
		5.6.1 Concept Description: A Comparison with Typical Machine Learning Methods 218
		5.6.2 Incremental and Parallel Mining of Concept Description 220
	5.7	Summary 220
		Exercises 222
		Bibliographic Notes 223
Chapter 6	Mini	ng Association Rules in Large Databases 225
	6.1	Association Rule Mining 226
		6.1.1 Market Basket Analysis: A Motivating Example for Association Rule Mining 226
		6.1.2 Basic Concepts 227
		6.1.3 Association Rule Mining: A Road Map 229
	6.2	Mining Single-Dimensional Boolean Association Rules from
		Transactional Databases 230
		6.2.1 The Apriori Algorithm: Finding Frequent Itemsets Using Candidate Generation 230
		6.2.2 Generating Association Rules from Frequent Itemsets 236
		6.2.3 Improving the Efficiency of Apriori 236
		6.2.4 Mining Frequent Itemsets without Candidate Generation 239 6.2.5 Iceberg Queries 243
	6.3	<del>-</del>
	0.5	Mining Multilevel Association Rules from Transaction  Databases 244

	<ul><li>6.3.1 Multilevel Association Rules 244</li><li>6.3.2 Approaches to Mining Multilevel Association Rules 246</li><li>6.3.3 Checking for Redundant Multilevel Association Rules 250</li></ul>
6.4	Mining Multidimensional Association Rules from Relational
	Databases and Data Warehouses 251
	<ul> <li>6.4.1 Multidimensional Association Rules 25 I</li> <li>6.4.2 Mining Multidimensional Association Rules Using Static Discretization of Quantitative Attributes 253</li> <li>6.4.3 Mining Quantitative Association Rules 254</li> </ul>
	<ul><li>6.4.3 Mining Quantitative Association Rules 254</li><li>6.4.4 Mining Distance-Based Association Rules 257</li></ul>
6.5	From Association Mining to Correlation Analysis 259
0.5	6.5.1 Strong Rules Are Not Necessarily Interesting: An Example 259 6.5.2 From Association Analysis to Correlation Analysis 260
6.6	Constraint-Based Association Mining 262
	<ul><li>6.6.1 Metarule-Guided Mining of Association Rules 263</li><li>6.6.2 Mining Guided by Additional Rule Constraints 265</li></ul>
6.7	Summary 269
	Exercises 271
	Bibliographic Notes 276
Chapter 7 Class	ssification and Prediction 279
7.1	ssification and Prediction 279 What Is Classification? What Is Prediction? 279
7.1	
7.2	Issues Regarding Classification and Prediction 282 7.2.1 Preparing the Data for Classification and Prediction 282
	7.2.2 Comparing Classification Methods 283
7.3	Classification by Decision Tree Induction 284
, , ,	7.3.1 Decision Tree Induction 285
	7.3.2 Tree Pruning 289
	7.3.3 Extracting Classification Rules from Decision Trees 290
	7.3.4 Enhancements to Basic Decision Tree Induction 291
	7.3.5 Scalability and Decision Tree Induction 292
	7.3.6 Integrating Data Warehousing Techniques and Decision Tree Induction 294
7.4	Bayesian Classification 296
	7.4.1 Bayes Theorem 296
	7.4.2 Naive Bayesian Classification 297
	7.4.3 Bayesian Belief Networks 299
	7.4.4 Training Bayesian Belief Networks 301
7.5	Classification by Backpropagation 303
	7.5.1 A Multilayer Feed-Forward Neural Network 303 7.5.2 Defining a Network Topology 304

		7.5.3 Backpropagation 305 7.5.4 Backpropagation and Interpretability 310
	7.6	Classification Based on Concepts from Association Rule
	7.0	Mining 311
	7.7	Other Classification Methods 314
		7.7.1 k-Nearest Neighbor Classifiers 314
		7.7.2 Case-Based Reasoning 315
		7.7.3 Genetic Algorithms 316 7.7.4 Rough Set Approach 316
		7.7.5 Fuzzy Set Approaches 317
	7.8	Prediction 319
		7.8.1 Linear and Multiple Regression 319
		7.8.2 Nonlinear Regression 321
		7.8.3 Other Regression Models 322
	7.9	Classifier Accuracy 322
		7.9.1 Estimating Classifier Accuracy 323
		<ul><li>7.9.2 Increasing Classifier Accuracy 324</li><li>7.9.3 Is Accuracy Enough to Judge a Classifier? 325</li></ul>
	7.10	Summary 326
	7.10	Exercises 328
		Bibliographic Notes 330
Chanter 8	Clus	ter Analysis 335
Chapter o	8.1	What Is Cluster Analysis? 335
	8.2	Types of Data in Cluster Analysis 338
		8.2.   Interval-Scaled Variables 339
		8.2.2 Binary Variables 341
		8.2.3 Nominal, Ordinal, and Ratio-Scaled Variables 343
		8.2.4 Variables of Mixed Types 345
	8.3	A Categorization of Major Clustering Methods 346
	8.4	Partitioning Methods 348
		8.4.1 Classical Partitioning Methods: k-Means and k-Medoids 349 8.4.2 Partitioning Methods in Large Databases: From k-Medoids to
		CLARANS 353
	8.5	Hierarchical Methods 354
		8.5.1 Agglomerative and Divisive Hierarchical Clustering 355
		8.5.2 BIRCH: Balanced Iterative Reducing and Clustering Using Hierarchies 357
		8.5.3 CURE: Clustering Using REpresentatives 358
		8.5.4 Chameleon: A Hierarchical Clustering Algorithm Using Dynamic Modeling 361

	0.6	Donaim Parad Mathada 242
	8.6	<ul> <li>Density-Based Methods 363</li> <li>8.6.1 DBSCAN: A Density-Based Clustering Method Based on Connected Regions with Sufficiently High Density 363</li> <li>8.6.2 OPTICS: Ordering Points To Identify the Clustering Structure 365</li> </ul>
		8.6.3 DENCLUE: Clustering Based on Density Distribution Functions 366
	8.7	<b>Grid-Based Methods 370</b> 8.7.1 STING: STatistical INformation Grid 370
		8.7.1 STING: Statistical Information Grid 370 8.7.2 WaveCluster: Clustering Using Wavelet Transformation 372 8.7.3 CLIQUE: Clustering High-Dimensional Space 374
	8.8	Model-Based Clustering Methods 376
		8.8.1 Statistical Approach 376 8.8.2 Neural Network Approach 379
	8.9	Outlier Analysis 381
		<ul><li>8.9.1 Statistical-Based Outlier Detection 382</li><li>8.9.2 Distance-Based Outlier Detection 384</li><li>8.9.3 Deviation-Based Outlier Detection 386</li></ul>
	8.10	Summary 388
		Exercises 389
		Bibliographic Notes 391
Chapter 9	Mini	ng Complex Types of Data 395
·	9.1	Multidimensional Analysis and Descriptive Mining of Complex
		Data Objects 396
		9.1.1 Generalization of Structured Data 396
		9.1.2 Aggregation and Approximation in Spatial and Multimedia Data Generalization 397
		9.1.3 Generalization of Object Identifiers and Class/Subclass Hierarchies 399
		9.1.4 Generalization of Class Composition Hierarchies 399
		9.1.5 Construction and Mining of Object Cubes 400

## 9.2 Mining Spatial Databases 405

Conquer 401

9.2.1 Spatial Data Cube Construction and Spatial OLAP 405

9.1.6 Generalization-Based Mining of Plan Databases by Divide-and-

- 9.2.2 Spatial Association Analysis 410
- 9.2.3 Spatial Clustering Methods 411
- 9.2.4 Spatial Classification and Spatial Trend Analysis 411
- 9.2.5 Mining Raster Databases 412

### 9.3 Mining Multimedia Databases 412

- 9.3.1 Similarity Search in Multimedia Data 412
- 9.3.2 Multidimensional Analysis of Multimedia Data 414
- 9.3.3 Classification and Prediction Analysis of Multimedia Data 416

9.4 Mining Time-Series and Sequence Data 418 9.4.1 Trend Analysis 418 9.4.2 Similarity Search in Time-Series Analysis 421 9.4.3 Sequential Pattern Mining 424 9.4.4 Periodicity Analysis 426 9.5 Mining Text Databases 428 9.5.1 Text Data Analysis and Information Retrieval 428 9.5.2 Text Mining: Keyword-Based Association and Document Classification 433 9.6 Mining the World Wide Web 435 9.6.1 Mining the Web's Link Structures to Identify Authoritative Web Pages 437 9.6.2 Automatic Classification of Web Documents 439 9.6.3 Construction of a Multilayered Web Information Base 440 9.6.4 Web Usage Mining 441 9.7 Summary 443 Exercises 444 Bibliographic Notes 446  Chapter 10 Applications and Trends in Data Mining 451 10.1.1 Data Mining Applications 451 10.1.2 Data Mining for Biomedical and DNA Data Analysis 451 10.1.3 Data Mining for Financial Data Analysis 453 10.1.3 Data Mining for the Retail Industry 455 10.1.4 Data Mining System Products and Research Prototypes 457
9.4.2 Similarity Search in Time-Series Analysis 421 9.4.3 Sequential Pattern Mining 424 9.4.4 Periodicity Analysis 426 9.5 Mining Text Databases 428 9.5.1 Text Data Analysis and Information Retrieval 428 9.5.2 Text Mining: Keyword-Based Association and Document Classification 433 9.6 Mining the World Wide Web 435 9.6.1 Mining the Web's Link Structures to Identify Authoritative Web Pages 437 9.6.2 Automatic Classification of Web Documents 439 9.6.3 Construction of a Multilayered Web Information Base 440 9.6.4 Web Usage Mining 441 9.7 Summary 443 Exercises 444 Bibliographic Notes 446  Chapter 10 Applications and Trends in Data Mining 451 10.1 Data Mining Applications 451 10.1.1 Data Mining for Biomedical and DNA Data Analysis 451 10.1.2 Data Mining for Financial Data Analysis 453 10.1.3 Data Mining for the Retail Industry 455 10.1.4 Data Mining for the Telecommunication Industry 456
9.4.3 Sequential Pattern Mining 424 9.4.4 Periodicity Analysis 426  9.5 Mining Text Databases 428 9.5.1 Text Data Analysis and Information Retrieval 428 9.5.2 Text Mining: Keyword-Based Association and Document Classification 433  9.6 Mining the World Wide Web 435 9.6.1 Mining the Web's Link Structures to Identify Authoritative Web Pages 437 9.6.2 Automatic Classification of Web Documents 439 9.6.3 Construction of a Multilayered Web Information Base 440 9.6.4 Web Usage Mining 441  9.7 Summary 443 Exercises 444 Bibliographic Notes 446  Chapter 10 Applications and Trends in Data Mining 451 10.1 Data Mining Applications 451 10.1.1 Data Mining for Biomedical and DNA Data Analysis 451 10.1.2 Data Mining for Financial Data Analysis 453 10.1.3 Data Mining for the Retail Industry 455 10.1.4 Data Mining for the Telecommunication Industry 456
9.4.4 Periodicity Analysis 426  9.5 Mining Text Databases 428  9.5.1 Text Data Analysis and Information Retrieval 428  9.5.2 Text Mining: Keyword-Based Association and Document Classification 433  9.6 Mining the World Wide Web 435  9.6.1 Mining the Web's Link Structures to Identify Authoritative Web Pages 437  9.6.2 Automatic Classification of Web Documents 439  9.6.3 Construction of a Multilayered Web Information Base 440  9.6.4 Web Usage Mining 441  9.7 Summary 443  Exercises 444  Bibliographic Notes 446  Chapter 10 Applications and Trends in Data Mining 45 I  10.1 Data Mining Applications 45 I  10.1.1 Data Mining for Biomedical and DNA Data Analysis 45 I  10.1.2 Data Mining for Financial Data Analysis 453 I  10.1.3 Data Mining for the Retail Industry 455 I  10.1.4 Data Mining for the Telecommunication Industry 456
9.5 Mining Text Databases 428 9.5.1 Text Data Analysis and Information Retrieval 428 9.5.2 Text Mining: Keyword-Based Association and Document Classification 433  9.6 Mining the World Wide Web 435 9.6.1 Mining the Web's Link Structures to Identify Authoritative Web Pages 437 9.6.2 Automatic Classification of Web Documents 439 9.6.3 Construction of a Multilayered Web Information Base 440 9.6.4 Web Usage Mining 441  9.7 Summary 443 Exercises 444 Bibliographic Notes 446  Chapter 10 Applications and Trends in Data Mining 45 I 10.1 Data Mining Applications 45 I 10.1.1 Data Mining for Biomedical and DNA Data Analysis 45 I 10.1.2 Data Mining for Financial Data Analysis 45 I 10.1.3 Data Mining for the Retail Industry 455 10.1.4 Data Mining for the Telecommunication Industry 456
9.5.1 Text Data Analysis and Information Retrieval 428 9.5.2 Text Mining: Keyword-Based Association and Document Classification 433  9.6 Mining the World Wide Web 435 9.6.1 Mining the Web's Link Structures to Identify Authoritative Web Pages 437 9.6.2 Automatic Classification of Web Documents 439 9.6.3 Construction of a Multilayered Web Information Base 440 9.6.4 Web Usage Mining 441  9.7 Summary 443 Exercises 444 Bibliographic Notes 446  Chapter 10 Applications and Trends in Data Mining 451 10.1.1 Data Mining Applications 451 10.1.2 Data Mining for Biomedical and DNA Data Analysis 451 10.1.3 Data Mining for Financial Data Analysis 453 10.1.3 Data Mining for the Retail Industry 455 10.1.4 Data Mining for the Telecommunication Industry 456
9.5.2 Text Mining: Keyword-Based Association and Document Classification 433  9.6 Mining the World Wide Web 435  9.6.1 Mining the Web's Link Structures to Identify Authoritative Web Pages 437  9.6.2 Automatic Classification of Web Documents 439  9.6.3 Construction of a Multilayered Web Information Base 440  9.6.4 Web Usage Mining 441  9.7 Summary 443  Exercises 444  Bibliographic Notes 446  Chapter 10 Applications and Trends in Data Mining 451  10.1.1 Data Mining Applications 451  10.1.2 Data Mining for Biomedical and DNA Data Analysis 451  10.1.3 Data Mining for Financial Data Analysis 453  10.1.3 Data Mining for the Retail Industry 455  10.1.4 Data Mining for the Telecommunication Industry 456
9.6.1 Mining the Web's Link Structures to Identify Authoritative Web Pages 437 9.6.2 Automatic Classification of Web Documents 439 9.6.3 Construction of a Multilayered Web Information Base 440 9.6.4 Web Usage Mining 441  9.7 Summary 443 Exercises 444 Bibliographic Notes 446  Chapter 10 Applications and Trends in Data Mining 451 10.1 Data Mining Applications 451 10.1.1 Data Mining for Biomedical and DNA Data Analysis 451 10.1.2 Data Mining for Financial Data Analysis 453 10.1.3 Data Mining for the Retail Industry 455 10.1.4 Data Mining for the Telecommunication Industry 456
Pages 437  9.6.2 Automatic Classification of Web Documents 439  9.6.3 Construction of a Multilayered Web Information Base 440  9.6.4 Web Usage Mining 441  9.7 Summary 443  Exercises 444  Bibliographic Notes 446  Chapter 10 Applications and Trends in Data Mining 451  10.1 Data Mining Applications 451  10.1.1 Data Mining for Biomedical and DNA Data Analysis 451  10.1.2 Data Mining for Financial Data Analysis 453  10.1.3 Data Mining for the Retail Industry 455  10.1.4 Data Mining for the Telecommunication Industry 456
9.6.3 Construction of a Multilayered Web Information Base 440 9.6.4 Web Usage Mining 441  9.7 Summary 443 Exercises 444 Bibliographic Notes 446  Chapter 10 Applications and Trends in Data Mining 451  10.1 Data Mining Applications 451  10.1.1 Data Mining for Biomedical and DNA Data Analysis 451 10.1.2 Data Mining for Financial Data Analysis 453 10.1.3 Data Mining for the Retail Industry 455 10.1.4 Data Mining for the Telecommunication Industry 456
9.6.4 Web Usage Mining 441  9.7 Summary 443 Exercises 444 Bibliographic Notes 446  Chapter 10 Applications and Trends in Data Mining 451  10.1 Data Mining Applications 451  10.1.1 Data Mining for Biomedical and DNA Data Analysis 451 10.1.2 Data Mining for Financial Data Analysis 453 10.1.3 Data Mining for the Retail Industry 455 10.1.4 Data Mining for the Telecommunication Industry 456
9.7 Summary 443 Exercises 444 Bibliographic Notes 446  Chapter 10 Applications and Trends in Data Mining 45 I 10.1 Data Mining Applications 45 I 10.1.1 Data Mining for Biomedical and DNA Data Analysis 45 I 10.1.2 Data Mining for Financial Data Analysis 453 10.1.3 Data Mining for the Retail Industry 455 10.1.4 Data Mining for the Telecommunication Industry 456
Exercises 444 Bibliographic Notes 446  Chapter 10 Applications and Trends in Data Mining 45 I  10.1 Data Mining Applications 45 I  10.1.1 Data Mining for Biomedical and DNA Data Analysis 45 I 10.1.2 Data Mining for Financial Data Analysis 453 10.1.3 Data Mining for the Retail Industry 455 10.1.4 Data Mining for the Telecommunication Industry 456
Chapter 10 Applications and Trends in Data Mining 45 I 10.1 Data Mining Applications 45 I 10.1.1 Data Mining for Biomedical and DNA Data Analysis 45 I 10.1.2 Data Mining for Financial Data Analysis 453 10.1.3 Data Mining for the Retail Industry 455 10.1.4 Data Mining for the Telecommunication Industry 456
Chapter 10 Applications and Trends in Data Mining 45 I  10.1 Data Mining Applications 45 I  10.1.1 Data Mining for Biomedical and DNA Data Analysis 45 I 10.1.2 Data Mining for Financial Data Analysis 453 10.1.3 Data Mining for the Retail Industry 455 10.1.4 Data Mining for the Telecommunication Industry 456
10.1 Data Mining Applications 45 I 10.1.1 Data Mining for Biomedical and DNA Data Analysis 45 I 10.1.2 Data Mining for Financial Data Analysis 453 10.1.3 Data Mining for the Retail Industry 455 10.1.4 Data Mining for the Telecommunication Industry 456
10.1 Data Mining Applications 45 I 10.1.1 Data Mining for Biomedical and DNA Data Analysis 45 I 10.1.2 Data Mining for Financial Data Analysis 453 10.1.3 Data Mining for the Retail Industry 455 10.1.4 Data Mining for the Telecommunication Industry 456
<ul> <li>10.1.1 Data Mining for Biomedical and DNA Data Analysis 451</li> <li>10.1.2 Data Mining for Financial Data Analysis 453</li> <li>10.1.3 Data Mining for the Retail Industry 455</li> <li>10.1.4 Data Mining for the Telecommunication Industry 456</li> </ul>
<ul><li>10.1.2 Data Mining for Financial Data Analysis 453</li><li>10.1.3 Data Mining for the Retail Industry 455</li><li>10.1.4 Data Mining for the Telecommunication Industry 456</li></ul>
<ul><li>10.1.3 Data Mining for the Retail Industry 455</li><li>10.1.4 Data Mining for the Telecommunication Industry 456</li></ul>
10.1.4 Data Mining for the Telecommunication Industry 456
·
10.2 Data Mining System Products and Research Prototypes 45/
<b>*</b> •
10.2.1 How to Choose a Data Mining System 458
10.2.2 Examples of Commercial Data Mining Systems 461
10.3 Additional Themes on Data Mining 462
10.3.1 Visual and Audio Data Mining 462
<ul><li>10.3.2 Scientific and Statistical Data Mining 464</li><li>10.3.3 Theoretical Foundations of Data Mining 470</li></ul>
10.3.4 Data Mining and Intelligent Query Answering 471
10.4 Social Impacts of Data Mining 472
·
10.4.1 Is Data Mining a Hype or a Persistent, Steadily Growing Business? 473 10.4.2 Is Data Mining Merely Managers' Business or Everyone's Business? 475
10.4.3 Is Data Mining a Threat to Privacy and Data Security? 476
10.5 Trends in Data Mining 478

10.6 Summary 480
Exercises 481
Bibliographic Notes 483

#### Appendix A An Introduction to Microsoft's OLE DB for Data Mining 485

- A.1 Creating a DMM object 486
- A.2 Inserting Training Data into the Model and Training the Model 488
- A.3 Using the Model 488

#### Appendix B An Introduction to DBMiner 493

- B.I System Architecture 494
- B.2 Input and Output 494
- B.3 Data Mining Tasks Supported by the System 495
- B.4 Support for Task and Method Selection 498
- B.5 Support of the KDD Process 499
- B.6 Main Applications 499
- B.7 Current Status 499

Bibliography 501 Index 533