

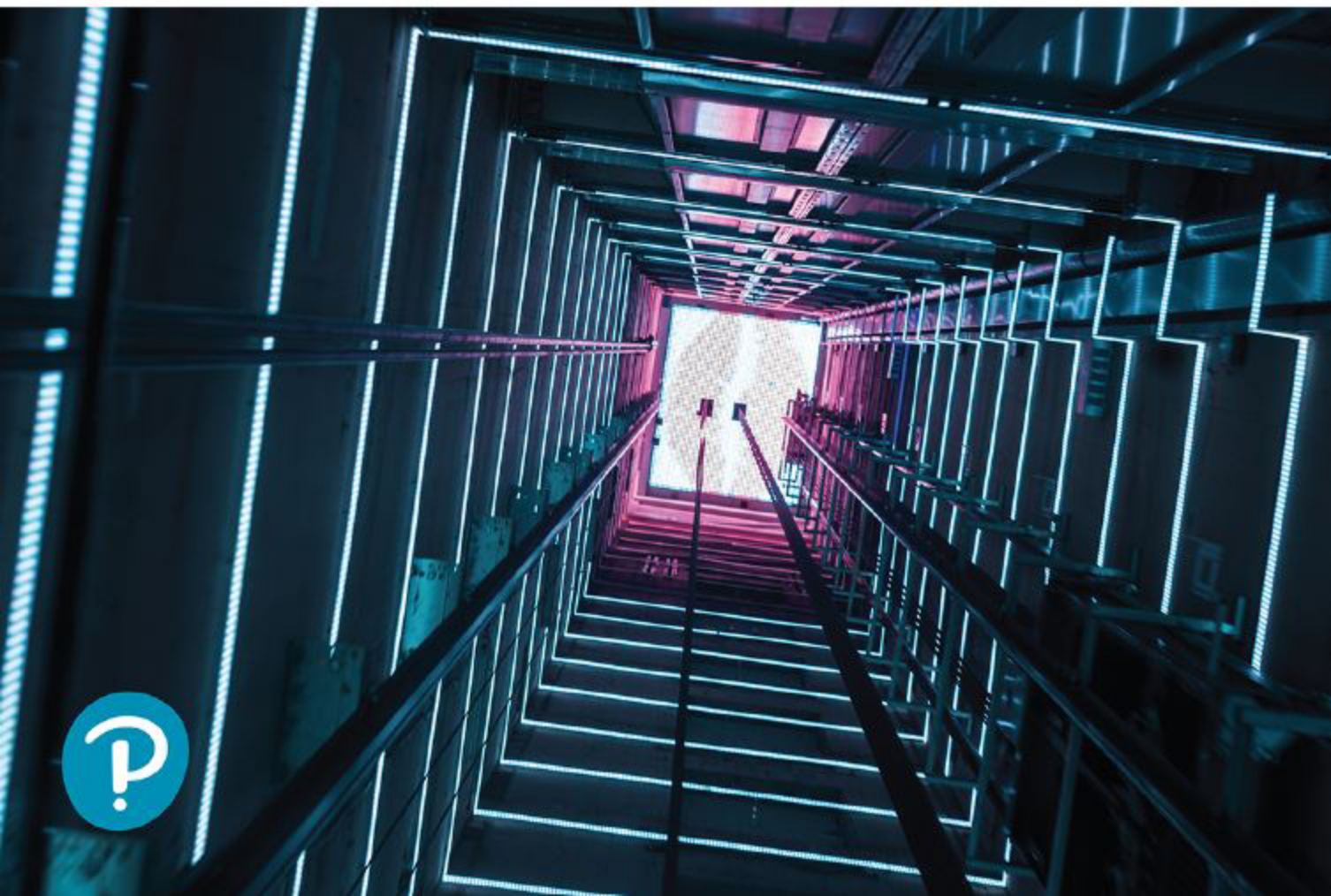
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# Analytics, Data Science, & Artificial Intelligence *Systems for Decision Support*

ELEVENTH EDITION

Ramesh Sharda • Dursun Delen • Efraim Turban



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GLOBAL EDITION

# ANALYTICS, DATA SCIENCE, & ARTIFICIAL INTELLIGENCE

SYSTEMS FOR DECISION SUPPORT

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# BRIEF CONTENTS

Preface 25  
About the Authors 34

## **PART I** Introduction to Analytics and AI 37

- Chapter 1** Overview of Business Intelligence, Analytics, Data Science, and Artificial Intelligence: Systems for Decision Support 38
- Chapter 2** Artificial Intelligence: Concepts, Drivers, Major Technologies, and Business Applications 109
- Chapter 3** Nature of Data, Statistical Modeling, and Visualization 153

## **PART II** Predictive Analytics/Machine Learning 229

- Chapter 4** Data Mining Process, Methods, and Algorithms 230
- Chapter 5** Machine-Learning Techniques for Predictive Analytics 287
- Chapter 6** Deep Learning and Cognitive Computing 351
- Chapter 7** Text Mining, Sentiment Analysis, and Social Analytics 424

## **PART III** Prescriptive Analytics and Big Data 495

- Chapter 8** Prescriptive Analytics: Optimization and Simulation 496
- Chapter 9** Big Data, Cloud Computing, and Location Analytics: Concepts and Tools 545

## **PART IV** Robotics, Social Networks, AI and IoT 615

- Chapter 10** Robotics: Industrial and Consumer Applications 616
- Chapter 11** Group Decision Making, Collaborative Systems, and AI Support 646
- Chapter 12** Knowledge Systems: Expert Systems, Recommenders, Chatbots, Virtual Personal Assistants, and Robo Advisors 684
- Chapter 13** The Internet of Things as a Platform for Intelligent Applications 723

## **PART V** Caveats of Analytics and AI 761

- Chapter 14** Implementation Issues: From Ethics and Privacy to Organizational and Societal Impacts 762

Glossary 806  
Index 821

Preface 25  
 About the Authors 34

## **PART I** Introduction to Analytics and AI 37

### **Chapter 1** Overview of Business Intelligence, Analytics, Data Science, and Artificial Intelligence: Systems for Decision Support 38

**1.1** Opening Vignette: How Intelligent Systems Work for KONE Elevators and Escalators Company 39

**1.2** Changing Business Environments and Evolving Needs for Decision Support and Analytics 41  
 Decision-Making Process 42  
 The Influence of the External and Internal Environments on the Process 42  
 Data and Its Analysis in Decision Making 43  
 Technologies for Data Analysis and Decision Support 43

**1.3** Decision-Making Processes and Computerized Decision Support Framework 45  
 Simon's Process: Intelligence, Design, and Choice 45  
 The Intelligence Phase: Problem (or Opportunity) Identification 46  
 ► **APPLICATION CASE 1.1** Making Elevators Go Faster! 47  
 The Design Phase 48  
 The Choice Phase 49  
 The Implementation Phase 49  
 The Classical Decision Support System Framework 50  
 A DSS Application 52  
 Components of a Decision Support System 54  
 The Data Management Subsystem 54  
 The Model Management Subsystem 55  
 ► **APPLICATION CASE 1.2** SNAP DSS Helps OneNet Make Telecommunications Rate Decisions 56  
 The User Interface Subsystem 56  
 The Knowledge-Based Management Subsystem 57

**1.4** Evolution of Computerized Decision Support to Business Intelligence/Analytics/Data Science 58  
 A Framework for Business Intelligence 61  
 The Architecture of BI 61  
 The Origins and Drivers of BI 62  
 Data Warehouse as a Foundation for Business Intelligence 63  
 Transaction Processing versus Analytic Processing 63  
 A Multimedia Exercise in Business Intelligence 64

- 1.5 Analytics Overview 66
  - Descriptive Analytics 68
    - ▶ **APPLICATION CASE 1.3** An Post and the Use of Data Visualization in Daily Postal Operations 68
    - ▶ **APPLICATION CASE 1.4** Siemens Reduces Cost with the Use of Data Visualization 69
  - Predictive Analytics 69
    - ▶ **APPLICATION CASE 1.5** SagaDigits and the Use of Predictive Analytics 70
  - Prescriptive Analytics 70
    - ▶ **APPLICATION CASE 1.6** A Specialty Steel Bar Company Uses Analytics to Determine Available-to-Promise Dates 71
- 1.6 Analytics Examples in Selected Domains 74
  - Sports Analytics—An Exciting Frontier for Learning and Understanding Applications of Analytics 74
  - Analytics Applications in Healthcare—Humana Examples 79
    - ▶ **APPLICATION CASE 1.7** Image Analysis Helps Estimate Plant Cover 86
- 1.7 Artificial Intelligence Overview 88
  - What Is Artificial Intelligence? 88
  - The Major Benefits of AI 88
  - The Landscape of AI 88
    - ▶ **APPLICATION CASE 1.8** AI Increases Passengers' Comfort and Security in Airports and Borders 90
  - The Three Flavors of AI Decisions 91
  - Autonomous AI 91
  - Societal Impacts 92
    - ▶ **APPLICATION CASE 1.9** Robots Took the Job of Camel-Racing Jockeys for Societal Benefits 94
- 1.8 Convergence of Analytics and AI 95
  - Major Differences between Analytics and AI 95
  - Why Combine Intelligent Systems? 96
  - How Convergence Can Help? 96
  - Big Data Is Empowering AI Technologies 96
  - The Convergence of AI and the IoT 97
  - The Convergence with Blockchain and Other Technologies 98
    - ▶ **APPLICATION CASE 1.10** Amazon Go Is Open for Business 98
  - IBM and Microsoft Support for Intelligent Systems Convergence 99
- 1.9 Overview of the Analytics Ecosystem 99
- 1.10 Plan of the Book 101
- 1.11 Resources, Links, and the Teradata University Network Connection 102
  - Resources and Links 102
  - Vendors, Products, and Demos 102
  - Periodicals 103
  - The Teradata University Network Connection 103



The Book's Web Site 103  
*Chapter Highlights* 103 • *Key Terms* 104  
*Questions for Discussion* 104 • *Exercises* 105  
*References* 106

## **Chapter 2 Artificial Intelligence: Concepts, Drivers, Major Technologies, and Business Applications 109**

- 2.1** Opening Vignette: INRIX Solves Transportation Problems 110
- 2.2** Introduction to Artificial Intelligence 112
  - Definitions 112
  - Major Characteristics of AI Machines 113
  - Major Elements of AI 113
  - AI Applications 114
  - Major Goals of AI 114
  - Drivers of AI 115
  - Benefits of AI 115
  - Some Limitations of AI Machines 117
  - Three Flavors of AI Decisions 117
  - Artificial Brain 118
- 2.3** Human and Computer Intelligence 119
  - What Is Intelligence? 119
  - How Intelligent Is AI? 120
  - Measuring AI 121
    - ▶ **APPLICATION CASE 2.1** How Smart Can a Vacuum Cleaner Be? 122
- 2.4** Major AI Technologies and Some Derivatives 123
  - Intelligent Agents 123
  - Machine Learning 124
    - ▶ **APPLICATION CASE 2.2** How Machine Learning Is Improving Work in Business 125
  - Machine and Computer Vision 126
  - Robotic Systems 127
  - Natural Language Processing 128
  - Knowledge and Expert Systems and Recommenders 129
  - Chatbots 130
  - Emerging AI Technologies 130
- 2.5** AI Support for Decision Making 131
  - Some Issues and Factors in Using AI in Decision Making 132
  - AI Support of the Decision-Making Process 132
  - Automated Decision Making 133
    - ▶ **APPLICATION CASE 2.3** How Companies Solve Real-World Problems Using Google's Machine-Learning Tools 133
  - Conclusion 134

- 2.6 AI Applications in Accounting 135
  - AI in Accounting: An Overview 135
  - AI in Big Accounting Companies 136
  - Accounting Applications in Small Firms 136
  - ▶ **APPLICATION CASE 2.4** How EY, Deloitte, and PwC Are Using AI 136
  - Job of Accountants 137
- 2.7 AI Applications in Financial Services 137
  - AI Activities in Financial Services 137
  - AI in Banking: An Overview 137
  - Illustrative AI Applications in Banking 138
  - Insurance Services 139
  - ▶ **APPLICATION CASE 2.5** AI in China's Financial Sector 140
- 2.8 AI in Human Resource Management (HRM) 141
  - AI in HRM: An Overview 141
  - AI in Onboarding 141
  - ▶ **APPLICATION CASE 2.6** How Alexander Mann Solutions (AMS) Is Using AI to Support the Recruiting Process 142
  - Introducing AI to HRM Operations 142
- 2.9 AI in Marketing, Advertising, and CRM 143
  - Overview of Major Applications 143
  - AI Marketing Assistants in Action 144
  - Customer Experiences and CRM 144
  - ▶ **APPLICATION CASE 2.7** Kraft Foods Uses AI for Marketing and CRM 145
  - Other Uses of AI in Marketing 146
- 2.10 AI Applications in Production-Operation Management (POM) 146
  - AI in Manufacturing 146
  - Implementation Model 147
  - Intelligent Factories 147
  - Logistics and Transportation 148
  - Chapter Highlights* 148 • *Key Terms* 149
  - Questions for Discussion* 149 • *Exercises* 150
  - References* 150

## Chapter 3 Nature of Data, Statistical Modeling, and Visualization 153

- 3.1 Opening Vignette: SiriusXM Attracts and Engages a New Generation of Radio Consumers with Data-Driven Marketing 154
- 3.2 Nature of Data 157
- 3.3 Simple Taxonomy of Data 161
  - ▶ **APPLICATION CASE 3.1** Verizon Answers the Call for Innovation: The Nation's Largest Network Provider Uses Advanced Analytics to Bring the Future to Its Customers 163



- 3.4 Art and Science of Data Preprocessing 165
  - ▶ **APPLICATION CASE 3.2** Improving Student Retention with Data-Driven Analytics 169
- 3.5 Statistical Modeling for Business Analytics 175
  - Descriptive Statistics for Descriptive Analytics 176
  - Measures of Centrality Tendency (Also Called *Measures of Location or Centrality*) 176
    - Arithmetic Mean 176
    - Median 177
    - Mode 177
  - Measures of Dispersion (Also Called *Measures of Spread or Decentrality*) 178
    - Range 178
    - Variance 178
    - Standard Deviation 179
    - Mean Absolute Deviation 179
  - Quartiles and Interquartile Range 179
  - Box-and-Whiskers Plot 179
  - Shape of a Distribution 181
    - ▶ **APPLICATION CASE 3.3** Town of Cary Uses Analytics to Analyze Data from Sensors, Assess Demand, and Detect Problems 186
- 3.6 Regression Modeling for Inferential Statistics 187
  - How Do We Develop the Linear Regression Model? 188
  - How Do We Know If the Model Is Good Enough? 189
  - What Are the Most Important Assumptions in Linear Regression? 190
  - Logistic Regression 191
  - Time-Series Forecasting 192
    - ▶ **APPLICATION CASE 3.4** Predicting NCAA Bowl Game Outcomes 193
- 3.7 Business Reporting 199
  - ▶ **APPLICATION CASE 3.5** Flood of Paper Ends at FEMA 201
- 3.8 Data Visualization 202
  - Brief History of Data Visualization 203
    - ▶ **APPLICATION CASE 3.6** Macfarlan Smith Improves Operational Performance Insight with Tableau Online 205
- 3.9 Different Types of Charts and Graphs 207
  - Basic Charts and Graphs 207
  - Specialized Charts and Graphs 208
  - Which Chart or Graph Should You Use? 210
- 3.10 Emergence of Visual Analytics 212
  - Visual Analytics 214
  - High-Powered Visual Analytics Environments 216
- 3.11 Information Dashboards 218

- ▶ **APPLICATION CASE 3.7** Flink Labs and Dashboard Applications Development 220
- Dashboard Design 220
- ▶ **APPLICATION CASE 3.8** Visual Analytics Helps Energy Supplier Make Better Connections 221
- What to Look for in a Dashboard 222
- Best Practices in Dashboard Design 223
- Benchmark Key Performance Indicators with Industry Standards 223
- Wrap the Dashboard Metrics with Contextual Metadata 223
- Validate the Dashboard Design by a Usability Specialist 223
- Prioritize and Rank Alerts/Exceptions Streamed to the Dashboard 224
- Enrich the Dashboard with Business-User Comments 224
- Present Information in Three Different Levels 224
- Pick the Right Visual Construct Using Dashboard Design Principles 224
- Provide for Guided Analytics 224
- Chapter Highlights* 224 • *Key Terms* 225
- Questions for Discussion* 226 • *Exercises* 226
- References* 228

## **PART II** Predictive Analytics/Machine Learning 229

### **Chapter 4** Data Mining Process, Methods, and Algorithms 230

- 4.1 Opening Vignette: Miami-Dade Police Department Is Using Predictive Analytics to Foresee and Fight Crime 231
- 4.2 Data Mining Concepts 234
  - ▶ **APPLICATION CASE 4.1** Visa Is Enhancing the Customer Experience While Reducing Fraud with Predictive Analytics and Data Mining 235
  - Definitions, Characteristics, and Benefits 237
  - How Data Mining Works 238
  - ▶ **APPLICATION CASE 4.2** American Honda Uses Advanced Analytics to Improve Warranty Claims 239
  - Data Mining versus Statistics 244
- 4.3 Data Mining Applications 244
  - ▶ **APPLICATION CASE 4.3** Predictive Analytic and Data Mining Help Stop Terrorist Funding 246
- 4.4 Data Mining Process 247
  - Step 1: Business Understanding 248
  - Step 2: Data Understanding 248
  - Step 3: Data Preparation 249
  - Step 4: Model Building 250
  - ▶ **APPLICATION CASE 4.4** Data Mining Helps in Cancer Research 250
  - Step 5: Testing and Evaluation 253

- Step 6: Deployment 253
- Other Data Mining Standardized Processes and Methodologies 253
- 4.5 Data Mining Methods 256**
  - Classification 256
  - Estimating the True Accuracy of Classification Models 257
  - Estimating the Relative Importance of Predictor Variables 260
  - Cluster Analysis for Data Mining 264
  - ▶ **APPLICATION CASE 4.5** Influence Health Uses Advanced Predictive Analytics to Focus on the Factors That Really Influence People's Healthcare Decisions 265
  - Association Rule Mining 268
- 4.6 Data Mining Software Tools 272**
  - ▶ **APPLICATION CASE 4.6** Data Mining Goes to Hollywood: Predicting Financial Success of Movies 275
- 4.7 Data Mining Privacy Issues, Myths, and Blunders 278**
  - ▶ **APPLICATION CASE 4.7** Predicting Customer Buying Patterns—The Target Story 279
  - Data Mining Myths and Blunders 280
  - Chapter Highlights 282 • Key Terms 283*
  - Questions for Discussion 283 • Exercises 284*
  - References 286*

## **Chapter 5 Machine-Learning Techniques for Predictive Analytics 287**

- 5.1 Opening Vignette: Predictive Modeling Helps Better Understand and Manage Complex Medical Procedures 288**
- 5.2 Basic Concepts of Neural Networks 291**
  - Biological versus Artificial Neural Networks 292
  - ▶ **APPLICATION CASE 5.1** Neural Networks Are Helping to Save Lives in the Mining Industry 294
- 5.3 Neural Network Architectures 295**
  - Kohonen's Self-Organizing Feature Maps 295
  - Hopfield Networks 296
  - ▶ **APPLICATION CASE 5.2** Predictive Modeling Is Powering the Power Generators 297
- 5.4 Support Vector Machines 299**
  - ▶ **APPLICATION CASE 5.3** Identifying Injury Severity Risk Factors in Vehicle Crashes with Predictive Analytics 300
  - Mathematical Formulation of SVM 305
  - Primal Form 305
  - Dual Form 305
  - Soft Margin 306
  - Nonlinear Classification 306
  - Kernel Trick 307

- 5.5 Process-Based Approach to the Use of SVM 307
    - Support Vector Machines versus Artificial Neural Networks 309
  - 5.6 Nearest Neighbor Method for Prediction 310
    - Similarity Measure: The Distance Metric 311
    - Parameter Selection 311
      - ▶ **APPLICATION CASE 5.4** Efficient Image Recognition and Categorization with *knn* 313
  - 5.7 Naïve Bayes Method for Classification 314
    - Bayes Theorem 315
    - Naïve Bayes Classifier 315
    - Process of Developing a Naïve Bayes Classifier 316
    - Testing Phase 317
      - ▶ **APPLICATION CASE 5.5** Predicting Disease Progress in Crohn’s Disease Patients: A Comparison of Analytics Methods 318
  - 5.8 Bayesian Networks 323
    - How Does BN Work? 323
    - How Can BN Be Constructed? 324
  - 5.9 Ensemble Modeling 329
    - Motivation—Why Do We Need to Use Ensembles? 329
    - Different Types of Ensembles 331
      - Bagging 332
      - Boosting 334
      - Variants of Bagging and Boosting 335
      - Stacking 336
      - Information Fusion 336
    - Summary—Ensembles Are Not Perfect! 337
      - ▶ **APPLICATION CASE 5.6** To Imprison or Not to Imprison: A Predictive Analytics–Based Decision Support System for Drug Courts 340
    - Chapter Highlights* 342 • *Key Terms* 344
    - Questions for Discussion* 344 • *Exercises* 345
    - Internet Exercises* 348 • *References* 349
- Chapter 6 Deep Learning and Cognitive Computing 351**
- 6.1 Opening Vignette: Fighting Fraud with Deep Learning and Artificial Intelligence 352
  - 6.2 Introduction to Deep Learning 356
    - ▶ **APPLICATION CASE 6.1** Finding the Next Football Star with Artificial Intelligence 359
  - 6.3 Basics of “Shallow” Neural Networks 361
    - ▶ **APPLICATION CASE 6.2** Gaming Companies Use Data Analytics to Score Points with Players 364
    - ▶ **APPLICATION CASE 6.3** Artificial Intelligence Helps Protect Animals from Extinction 369

- 6.4 Process of Developing Neural Network–Based Systems 370
  - Learning Process in ANN 371
  - Backpropagation for ANN Training 372
- 6.5 Illuminating the Black Box of ANN 376
  - ▶ **APPLICATION CASE 6.4** Sensitivity Analysis Reveals Injury Severity Factors in Traffic Accidents 377
- 6.6 Deep Neural Networks 379
  - Feedforward Multilayer Perceptron (MLP)-Type Deep Networks 379
  - Impact of Random Weights in Deep MLP 380
  - More Hidden Layers versus More Neurons? 381
  - ▶ **APPLICATION CASE 6.5** Georgia DOT Variable Speed Limit Analytics Help Solve Traffic Congestions 382
- 6.7 Convolutional Neural Networks 385
  - Convolution Function 385
  - Pooling 388
  - Image Processing Using Convolutional Networks 389
  - ▶ **APPLICATION CASE 6.6** From Image Recognition to Face Recognition 392
  - Text Processing Using Convolutional Networks 393
- 6.8 Recurrent Networks and Long Short-Term Memory Networks 396
  - ▶ **APPLICATION CASE 6.7** Deliver Innovation by Understanding Customer Sentiments 399
  - LSTM Networks Applications 401
- 6.9 Computer Frameworks for Implementation of Deep Learning 404
  - Torch 404
  - Caffe 404
  - TensorFlow 405
  - Theano 405
  - Keras: An Application Programming Interface 406
- 6.10 Cognitive Computing 406
  - How Does Cognitive Computing Work? 407
  - How Does Cognitive Computing Differ from AI? 408
  - Cognitive Search 410
  - IBM Watson: Analytics at Its Best 411
  - ▶ **APPLICATION CASE 6.8** IBM Watson Competes against the Best at *Jeopardy!* 412
  - How Does Watson Do It? 413
  - What Is the Future for Watson? 413
  - Chapter Highlights* 417 • *Key Terms* 419
  - Questions for Discussion* 419 • *Exercises* 420
  - References* 421

## Chapter 7 Text Mining, Sentiment Analysis, and Social Analytics 424

- 7.1 Opening Vignette: Amadori Group Converts Consumer Sentiments into Near-Real-Time Sales 425
- 7.2 Text Analytics and Text Mining Overview 428
  - ▶ **APPLICATION CASE 7.1** Netflix: Using Big Data to Drive Big Engagement: Unlocking the Power of Analytics to Drive Content and Consumer Insight 431
- 7.3 Natural Language Processing (NLP) 433
  - ▶ **APPLICATION CASE 7.2** AMC Networks Is Using Analytics to Capture New Viewers, Predict Ratings, and Add Value for Advertisers in a Multichannel World 435
- 7.4 Text Mining Applications 438
  - Marketing Applications 439
  - Security Applications 439
  - Biomedical Applications 440
  - ▶ **APPLICATION CASE 7.3** Mining for Lies 440
  - Academic Applications 443
  - ▶ **APPLICATION CASE 7.4** The Magic behind the Magic: Instant Access to Information Helps the Orlando Magic Up Their Game and the Fan's Experience 444
- 7.5 Text Mining Process 446
  - Task 1: Establish the Corpus 446
  - Task 2: Create the Term–Document Matrix 447
  - Task 3: Extract the Knowledge 449
  - ▶ **APPLICATION CASE 7.5** Research Literature Survey with Text Mining 451
- 7.6 Sentiment Analysis 454
  - ▶ **APPLICATION CASE 7.6** Creating a Unique Digital Experience to Capture Moments That Matter at Wimbledon 455
  - Sentiment Analysis Applications 458
  - Sentiment Analysis Process 460
  - Methods for Polarity Identification 462
  - Using a Lexicon 462
  - Using a Collection of Training Documents 463
  - Identifying Semantic Orientation of Sentences and Phrases 464
  - Identifying Semantic Orientation of Documents 464
- 7.7 Web Mining Overview 465
  - Web Content and Web Structure Mining 467
- 7.8 Search Engines 469
  - Anatomy of a Search Engine 470
  - 1. Development Cycle 470
  - 2. Response Cycle 471
  - Search Engine Optimization 472
  - Methods for Search Engine Optimization 473



- ▶ **APPLICATION CASE 7.7** Delivering Individualized Content and Driving Digital Engagement: How Barbour Collected More Than 49,000 New Leads in One Month with Teradata Interactive 475
- 7.9 Web Usage Mining (Web Analytics) 477
  - Web Analytics Technologies 477
  - Web Analytics Metrics 478
  - Web Site Usability 478
  - Traffic Sources 479
  - Visitor Profiles 480
  - Conversion Statistics 480
- 7.10 Social Analytics 482
  - Social Network Analysis 482
  - Social Network Analysis Metrics 483
  - ▶ **APPLICATION CASE 7.8** Tito's Vodka Establishes Brand Loyalty with an Authentic Social Strategy 483
  - Connections 486
  - Distributions 486
  - Segmentation 487
  - Social Media Analytics 487
  - How Do People Use Social Media? 488
  - Measuring the Social Media Impact 489
  - Best Practices in Social Media Analytics 489
  - Chapter Highlights* 491 • *Key Terms* 492
  - Questions for Discussion* 492 • *Exercises* 492
  - References* 493

## **PART III** Prescriptive Analytics and Big Data 495

### **Chapter 8** Prescriptive Analytics: Optimization and Simulation 496

- 8.1 Opening Vignette: School District of Philadelphia Uses Prescriptive Analytics to Find Optimal Solution for Awarding Bus Route Contracts 497
- 8.2 Model-Based Decision Making 498
  - ▶ **APPLICATION CASE 8.1** Canadian Football League Optimizes Game Schedule 499
  - Prescriptive Analytics Model Examples 501
  - Identification of the Problem and Environmental Analysis 501
  - ▶ **APPLICATION CASE 8.2** Ingram Micro Uses Business Intelligence Applications to Make Pricing Decisions 502
  - Model Categories 503
- 8.3 Structure of Mathematical Models for Decision Support 505
  - The Components of Decision Support Mathematical Models 505
  - The Structure of Mathematical Models 506

- 8.4 Certainty, Uncertainty, and Risk 507
  - Decision Making under Certainty 507
  - Decision Making under Uncertainty 508
  - Decision Making under Risk (Risk Analysis) 508
  - ▶ **APPLICATION CASE 8.3** American Airlines Uses Should-Cost Modeling to Assess the Uncertainty of Bids for Shipment Routes 508
- 8.5 Decision Modeling with Spreadsheets 509
  - ▶ **APPLICATION CASE 8.4** Pennsylvania Adoption Exchange Uses Spreadsheet Model to Better Match Children with Families 510
  - ▶ **APPLICATION CASE 8.5** Metro Meals on Wheels Treasure Valley Uses Excel to Find Optimal Delivery Routes 511
- 8.6 Mathematical Programming Optimization 513
  - ▶ **APPLICATION CASE 8.6** Mixed-Integer Programming Model Helps the University of Tennessee Medical Center with Scheduling Physicians 514
  - Linear Programming Model 515
  - Modeling in LP: An Example 516
  - Implementation 520
- 8.7 Multiple Goals, Sensitivity Analysis, What-If Analysis, and Goal Seeking 522
  - Multiple Goals 522
  - Sensitivity Analysis 523
  - What-If Analysis 524
  - Goal Seeking 525
- 8.8 Decision Analysis with Decision Tables and Decision Trees 526
  - Decision Tables 526
  - Decision Trees 528
- 8.9 Introduction to Simulation 529
  - Major Characteristics of Simulation 529
  - ▶ **APPLICATION CASE 8.7** Steel Tubing Manufacturer Uses a Simulation-Based Production Scheduling System 529
  - Advantages of Simulation 530
  - Disadvantages of Simulation 531
  - The Methodology of Simulation 531
  - Simulation Types 532
  - Monte Carlo Simulation 533
  - Discrete Event Simulation 534
  - ▶ **APPLICATION CASE 8.8** Cosan Improves Its Renewable Energy Supply Chain Using Simulation 534
- 8.10 Visual Interactive Simulation 536
  - Conventional Simulation Inadequacies 536
  - Visual Interactive Simulation 536

Visual Interactive Models and DSS 536

Simulation Software 537

▶ **APPLICATION CASE 8.9** Improving Job-Shop Scheduling Decisions through RFID: A Simulation-Based Assessment 537

*Chapter Highlights* 541 • *Key Terms* 541

*Questions for Discussion* 541 • *Exercises* 542

*References* 544

## Chapter 9 Big Data, Cloud Computing, and Location Analytics: Concepts and Tools 545

9.1 Opening Vignette: Analyzing Customer Churn in a Telecom Company Using Big Data Methods 546

9.2 Definition of Big Data 549

The “V”s That Define Big Data 550

▶ **APPLICATION CASE 9.1** Alternative Data for Market Analysis or Forecasts 553

9.3 Fundamentals of Big Data Analytics 555

Business Problems Addressed by Big Data Analytics 557

▶ **APPLICATION CASE 9.2** Big Data and Retail Business: The Rise of ABEJA 558

9.4 Big Data Technologies 559

MapReduce 559

Why Use MapReduce? 559

Hadoop 560

How Does Hadoop Work? 561

Hadoop Technical Components 561

Hadoop: The Pros and Cons 563

NoSQL 564

▶ **APPLICATION CASE 9.3** eBay’s Big Data Solution 565

▶ **APPLICATION CASE 9.4** Understanding Quality and Reliability of Healthcare Support Information on Twitter 567

9.5 Big Data and Data Warehousing 568

Use Cases for Hadoop 569

Use Cases for Data Warehousing 570

The Gray Areas (Any One of the Two Would Do the Job) 571

Coexistence of Hadoop and Data Warehouse 572

9.6 In-Memory Analytics and Apache Spark™ 573

▶ **APPLICATION CASE 9.5** Databrick’s Apache Spark™: Asia-Pacific Big Data Processing in Action 574

Architecture of Apache Spark™ 574

Getting Started with Apache Spark™ 575

9.7 Big Data and Stream Analytics 579

Stream Analytics versus Perpetual Analytics 580

Critical Event Processing 581

Data Stream Mining 582

Applications of Stream Analytics 582

	e-Commerce	582
	Telecommunications	582
	▶ <b>APPLICATION CASE 9.6</b> Salesforce Is Using Streaming Data to Enhance Customer Value	583
	Law Enforcement and Cybersecurity	583
	Power Industry	584
	Financial Services	584
	Health Sciences	584
	Government	584
<b>9.8</b>	<b>Big Data Vendors and Platforms</b>	<b>585</b>
	Infrastructure Services Providers	586
	Analytics Solution Providers	586
	Business Intelligence Providers Incorporating Big Data	587
	▶ <b>APPLICATION CASE 9.7</b> Using Social Media for Nowcasting Flu Activity	587
	▶ <b>APPLICATION CASE 9.8</b> Analyzing Disease Patterns from an Electronic Medical Records Data Warehouse	590
<b>9.9</b>	<b>Cloud Computing and Business Analytics</b>	<b>593</b>
	Data as a Service (DaaS)	594
	Software as a Service (SaaS)	595
	Platform as a Service (PaaS)	595
	Infrastructure as a Service (IaaS)	595
	Essential Technologies for Cloud Computing	596
	▶ <b>APPLICATION CASE 9.9</b> Major West Coast Utility Uses Cloud-Mobile Technology to Provide Real-Time Incident Reporting	597
	Cloud Deployment Models	599
	Major Cloud Platform Providers in Analytics	599
	Analytics as a Service (AaaS)	600
	Representative Analytics as a Service Offerings	600
	Illustrative Analytics Applications Employing the Cloud Infrastructure	601
	Using Azure IOT, Stream Analytics, and Machine Learning to Improve Mobile Health Care Services	601
	Gulf Air Uses Big Data to Get Deeper Customer Insight	602
	Chime Enhances Customer Experience Using Snowflake	602
<b>9.10</b>	<b>Location-Based Analytics for Organizations</b>	<b>603</b>
	Geospatial Analytics	603
	▶ <b>APPLICATION CASE 9.10</b> GIS and the Indian Retail Industry	606
	▶ <b>APPLICATION CASE 9.11</b> Starbucks Exploits GIS and Analytics to Grow Worldwide	606
	Real-Time Location Intelligence	608
	Analytics Applications for Consumers	609
	<i>Chapter Highlights</i>	610 • <i>Key Terms</i>
	<i>Questions for Discussion</i>	611 • <i>Exercises</i>
	<i>References</i>	612

## **PART IV** Robotics, Social Networks, AI, and IoT 615

### **Chapter 10** Robotics: Industrial and Consumer Applications 616

- 10.1** Opening Vignette: Robots Provide Emotional Support to Patients and Children 617
- 10.2** Overview of Robotics 620
- 10.3** History of Robotics 620
- 10.4** Illustrative Applications of Robotics 622
  - Changing Precision Technology 622
  - Adidas 622
  - BMW Employs Collaborative Robots 623
  - Tega 623
  - San Francisco Burger Eatery 624
  - Spyce 624
  - Mahindra & Mahindra Ltd. 625
  - Robots in the Defense Industry 625
  - Pepper 626
  - Da Vinci Surgical System 628
  - Snoo—A Robotic Crib 629
  - MEDi 629
  - Care-E Robot 629
  - AGROBOT 630
- 10.5** Components of Robots 631
- 10.6** Various Categories of Robots 632
- 10.7** Autonomous Cars: Robots in Motion 633
  - Autonomous Vehicle Development 634
  - Issues with Self-Driving Cars 635
- 10.8** Impact of Robots on Current and Future Jobs 636
- 10.9** Legal Implications of Robots and Artificial Intelligence 639
  - Tort Liability 639
  - Patents 639
  - Property 640
  - Taxation 640
  - Practice of Law 640
  - Constitutional Law 641
  - Professional Certification 641
  - Law Enforcement 641
  - Chapter Highlights* 642 • *Key Terms* 642
  - Questions for Discussion* 642 • *Exercises* 643
  - References* 643

- Chapter 11 Group Decision Making, Collaborative Systems, and AI Support 646**
- 11.1** Opening Vignette: Hendrick Motorsports Excels with Collaborative Teams 647
  - 11.2** Making Decisions in Groups: Characteristics, Process, Benefits, and Dysfunctions 649
    - Characteristics of Group Work 649
    - Types of Decisions Made by Groups 650
    - Group Decision-Making Process 650
    - Benefits and Limitations of Group Work 651
  - 11.3** Supporting Group Work and Team Collaboration with Computerized Systems 652
    - Overview of Group Support Systems (GSS) 653
    - Time/Place Framework 653
    - Group Collaboration for Decision Support 654
  - 11.4** Electronic Support for Group Communication and Collaboration 655
    - Groupware for Group Collaboration 655
    - Synchronous versus Asynchronous Products 655
    - Virtual Meeting Systems 656
    - Collaborative Networks and Hubs 658
    - Collaborative Hubs 658
    - Social Collaboration 658
    - Sample of Popular Collaboration Software 659
  - 11.5** Direct Computerized Support for Group Decision Making 659
    - Group Decision Support Systems (GDSS) 660
    - Characteristics of GDSS 661
    - Supporting the Entire Decision-Making Process 661
    - Brainstorming for Idea Generation and Problem Solving 663
    - Group Support Systems 664
  - 11.6** Collective Intelligence and Collaborative Intelligence 665
    - Definitions and Benefits 665
    - Computerized Support to Collective Intelligence 665
    - ▶ **APPLICATION CASE 11.1** Collaborative Modeling for Optimal Water Management: The Oregon State University Project 666
    - How Collective Intelligence May Change Work and Life 667
    - Collaborative Intelligence 668
    - How to Create Business Value from Collaboration: The IBM Study 668



- 11.7 Crowdsourcing as a Method for Decision Support 669
  - The Essentials of Crowdsourcing 669
  - Crowdsourcing for Problem-Solving and Decision Support 670
  - Implementing Crowdsourcing for Problem Solving 671
  - ▶ **APPLICATION CASE 11.2** How InnoCentive Helped GSK Solve a Difficult Problem 672
- 11.8 Artificial Intelligence and Swarm AI Support of Team Collaboration and Group Decision Making 672
  - AI Support of Group Decision Making 673
  - AI Support of Team Collaboration 673
  - Swarm Intelligence and Swarm AI 675
  - ▶ **APPLICATION CASE 11.3** XPRIZE Optimizes Visioneering 675
- 11.9 Human–Machine Collaboration and Teams of Robots 676
  - Human–Machine Collaboration in Cognitive Jobs 677
  - Robots as Coworkers: Opportunities and Challenges 677
  - Teams of collaborating Robots 678
  - Chapter Highlights 680 • Key Terms 681*
  - Questions for Discussion 681 • Exercises 681*
  - References 682*

## Chapter 12 Knowledge Systems: Expert Systems, Recommenders, Chatbots, Virtual Personal Assistants, and Robo Advisors 684

- 12.1 Opening Vignette: Sephora Excels with Chatbots 685
- 12.2 Expert Systems and Recommenders 686
  - Basic Concepts of Expert Systems (ES) 686
  - Characteristics and Benefits of ES 688
  - Typical Areas for ES Applications 689
  - Structure and Process of ES 689
  - ▶ **APPLICATION CASE 12.1** ES Aid in Identification of Chemical, Biological, and Radiological Agents 691
  - Why the Classical Type of ES Is Disappearing 691
  - ▶ **APPLICATION CASE 12.2** VisiRule 692
  - Recommendation Systems 693
  - ▶ **APPLICATION CASE 12.3** Netflix Recommender: A Critical Success Factor 694
- 12.3 Concepts, Drivers, and Benefits of Chatbots 696
  - What Is a Chatbot? 696
  - Chatbot Evolution 696
  - Components of Chatbots and the Process of Their Use 698
  - Drivers and Benefits 699
  - Representative Chatbots from around the World 699
- 12.4 Enterprise Chatbots 700
  - The Interest of Enterprises in Chatbots 700

	Enterprise Chatbots: Marketing and Customer Experience	701
	▶ <b>APPLICATION CASE 12.4</b> WeChat's Super Chatbot	702
	▶ <b>APPLICATION CASE 12.5</b> How Vera Gold Mark Uses Chatbots to Increase Sales	703
	Enterprise Chatbots: Financial Services	704
	Enterprise Chatbots: Service Industries	704
	Chatbot Platforms	705
	▶ <b>APPLICATION CASE 12.6</b> Transavia Airlines Uses Bots for Communication and Customer Care Delivery	705
	Knowledge for Enterprise Chatbots	707
<b>12.5</b>	Virtual Personal Assistants	708
	Assistant for Information Search	708
	If You Were Mark Zuckerberg, Facebook CEO	708
	Amazon's Alexa and Echo	708
	Apple's Siri	711
	Google Assistant	711
	Other Personal Assistants	711
	Competition among Large Tech Companies	711
	Knowledge for Virtual Personal Assistants	711
<b>12.6</b>	Chatbots as Professional Advisors (Robo Advisors)	712
	Robo Financial Advisors	712
	Evolution of Financial Robo Advisors	712
	Robo Advisors 2.0: Adding the Human Touch	712
	▶ <b>APPLICATION CASE 12.7</b> Barclays: AI and Chatbots in Banking	713
	Managing Mutual Funds Using AI	714
	Other Professional Advisors	714
	IBM Watson	716
<b>12.7</b>	<b>Implementation Issues</b>	<b>716</b>
	Technology Issues	716
	Disadvantages and Limitations of Bots	717
	Quality of Chatbots	717
	Setting Up Alexa's Smart Home System	718
	Constructing Bots	718
	<i>Chapter Highlights</i>	719 • <i>Key Terms</i> 719
	<i>Questions for Discussion</i>	720 • <i>Exercises</i> 720
	<i>References</i>	721

## Chapter 13 The Internet of Things as a Platform for Intelligent Applications 723

<b>13.1</b>	Opening Vignette: CNH Industrial Uses the Internet of Things to Excel	724
<b>13.2</b>	Essentials of IoT	725
	Definitions and Characteristics	726

- The IoT Ecosystem 727
- Structure of IoT Systems 727
- 13.3 Major Benefits and Drivers of IoT 730**
  - Major Benefits of IoT 730
  - Major Drivers of IoT 731
  - Opportunities 731
- 13.4 How IoT Works 732**
  - IoT and Decision Support 732
- 13.5 Sensors and Their Role in IoT 733**
  - Brief Introduction to Sensor Technology 733
  - ▶ **APPLICATION CASE 13.1 Using Sensors, IoT, and AI for Environmental Control at the Athens International Airport 733**
  - How Sensors Work with IoT 734
  - ▶ **APPLICATION CASE 13.2 Rockwell Automation Monitors Expensive Oil and Gas Exploration Assets to Predict Failures 734**
  - Sensor Applications and Radio-Frequency Identification (RFID) Sensors 735
- 13.6 Selected IoT Applications 737**
  - A Large-Scale IoT in Action 737
  - Examples of Other Existing Applications 737
- 13.7 Smart Homes and Appliances 739**
  - Typical Components of Smart Homes 739
  - Smart Appliances 740
  - A Smart Home Is Where the Bot Is 742
  - Barriers to Smart Home Adoption 743
- 13.8 Smart Cities and Factories 743**
  - ▶ **APPLICATION CASE 13.3 Amsterdam on the Road to Become a Smart City 744**
  - Smart Buildings: From Automated to Cognitive Buildings 745
  - Smart Components in Smart Cities and Smart Factories 745
  - ▶ **APPLICATION CASE 13.4 How IBM Is Making Cities Smarter Worldwide 747**
  - Improving Transportation in the Smart City 748
  - Combining Analytics and IoT in Smart City Initiatives 749
  - Bill Gates' Futuristic Smart City 749
  - Technology Support for Smart Cities 749
- 13.9 Autonomous (Self-Driving) Vehicles 750**
  - The Developments of Smart Vehicles 750
  - ▶ **APPLICATION CASE 13.5 Waymo and Autonomous Vehicles 751**
  - Flying Cars 753
  - Implementation Issues in Autonomous Vehicles 753

- 13.10 Implementing IoT and Managerial Considerations 753
  - Major Implementation Issues 754
  - Strategy for Turning Industrial IoT into Competitive Advantage 755
  - The Future of the IoT 756
  - Chapter Highlights* 757 • *Key Terms* 757
  - Questions for Discussion* 758 • *Exercises* 758
  - References* 758

## **PART V** **Caveats of Analytics and AI 761**

### **Chapter 14 Implementation Issues: From Ethics and Privacy to Organizational and Societal Impacts 762**

- 14.1 Opening Vignette: Why Did Uber Pay \$245 Million to Waymo? 763
- 14.2 Implementing Intelligent Systems: An Overview 765
  - The Intelligent Systems Implementation Process 765
  - The Impacts of Intelligent Systems 766
- 14.3 Legal, Privacy, and Ethical Issues 767
  - Legal Issues 767
  - Privacy Issues 768
  - Who Owns Our Private Data? 771
  - Ethics Issues 771
  - Ethical Issues of Intelligent Systems 772
  - Other Topics in Intelligent Systems Ethics 772
- 14.4 Successful Deployment of Intelligent Systems 773
  - Top Management and Implementation 774
  - System Development Implementation Issues 774
  - Connectivity and Integration 775
  - Security Protection 775
  - Leveraging Intelligent Systems in Business 775
  - Intelligent System Adoption 776
- 14.5 Impacts of Intelligent Systems on Organizations 776
  - New Organizational Units and Their Management 777
  - Transforming Businesses and Increasing Competitive Advantage 777
  - **APPLICATION CASE 14.1** How 1-800-Flowers.com Uses Intelligent Systems for Competitive Advantage 778
  - Redesign of an Organization through the Use of Analytics 779
  - Intelligent Systems' Impact on Managers' Activities, Performance, and Job Satisfaction 780
  - Impact on Decision Making 781
  - Industrial Restructuring 782

<b>14.6</b>	<b>Impacts on Jobs and Work</b>	<b>783</b>	
	An Overview	783	
	Are Intelligent Systems Going to Take Jobs—My Job?	783	
	AI Puts Many Jobs at Risk	784	
	▶ <b>APPLICATION CASE 14.2</b> White-Collar Jobs That Robots Have Already Taken	784	
	Which Jobs Are Most in Danger? Which Ones Are Safe?	785	
	Intelligent Systems May Actually Add Jobs	786	
	Jobs and the Nature of Work Will Change	787	
	Conclusion: Let's Be Optimistic!	788	
<b>14.7</b>	<b>Potential Dangers of Robots, AI, and Analytical Modeling</b>	<b>789</b>	
	Position of AI Dystopia	789	
	The AI Utopia's Position	789	
	The Open AI Project and the Friendly AI	790	
	The O'Neil Claim of Potential Analytics' Dangers	791	
<b>14.8</b>	<b>Relevant Technology Trends</b>	<b>792</b>	
	Gartner's Top Strategic Technology Trends for 2018 and 2019	792	
	Other Predictions Regarding Technology Trends	793	
	Summary: Impact on AI and Analytics	794	
	Ambient Computing (Intelligence)	794	
<b>14.9</b>	<b>Future of Intelligent Systems</b>	<b>796</b>	
	What Are the Major U.S. High-Tech Companies Doing in the Intelligent Technologies Field?	796	
	AI Research Activities in China	797	
	▶ <b>APPLICATION CASE 14.3</b> How Alibaba.com Is Conducting AI	798	
	The U.S.–China Competition: Who Will Control AI?	800	
	The Largest Opportunity in Business	800	
	Conclusion	800	
	<i>Chapter Highlights</i>	801 • <i>Key Terms</i>	802
	<i>Questions for Discussion</i>	802 • <i>Exercises</i>	802
	<i>References</i>	803	
	Glossary	806	
	Index	821	

Analytics has become the technology driver of this decade. Companies such as IBM, Oracle, Microsoft, and others are creating new organizational units focused on analytics that help businesses become more effective and efficient in their operations. Decision makers are using data and computerized tools to make better decisions. Even consumers are using analytics tools directly or indirectly to make decisions on routine activities such as shopping, health care, and entertainment. The field of business analytics (BA)/data science (DS)/decision support systems (DSS)/business intelligence (BI) is evolving rapidly to become more focused on innovative methods and applications to utilize data streams that were not even captured some time back, much less analyzed in any significant way. New applications emerge daily in customer relationship management, banking and finance, health care and medicine, sports and entertainment, manufacturing and supply chain management, utilities and energy, and virtually every industry imaginable.

The theme of this revised edition is analytics, data science, and AI for enterprise decision support. In addition to traditional decision support applications, this edition expands the reader's understanding of the various types of analytics by providing examples, products, services, and exercises by means of introducing AI, machine-learning, robotics, chatbots, IoT, and Web/Internet-related enablers throughout the text. We highlight these technologies as emerging components of modern-day business analytics systems. AI technologies have a major impact on decision making by enabling autonomous decisions and by supporting steps in the process of making decisions. AI and analytics support each other by creating a synergy that assists decision making.

The purpose of this book is to introduce the reader to the technologies that are generally and collectively called *analytics* (or *business analytics*) but have been known by other names such as decision support systems, executive information systems, and business intelligence, among others. We use these terms interchangeably. This book presents the fundamentals of the methods, methodologies, and techniques used to design and develop these systems. In addition, we introduce the essentials of AI both as it relates to analytics as well as a standalone discipline for decision support.

We follow an EEE approach to introducing these topics: **Exposure, Experience, and Explore**. The book primarily provides **exposure** to various analytics techniques and their applications. The idea is that a student will be inspired to learn from how other organizations have employed analytics to make decisions or to gain a competitive edge. We believe that such **exposure** to what is being done with analytics and how it can be achieved is the key component of learning about analytics. In describing the techniques, we also introduce specific software tools that can be used for developing such applications. The book is not limited to any one software tool, so the students can **experience** these techniques using any number of available software tools. Specific suggestions are given in each chapter, but the student and the professor are able to use this book with many different software tools. Our book's companion Web site will include specific software guides, but students can gain **experience** with these techniques in many different ways. Finally, we hope that this **exposure** and **experience** enable and motivate readers to **explore** the potential of these techniques in their own domain. To facilitate such **exploration**, we include exercises that direct them to Teradata University Network and other sites as well that include team-oriented exercises where appropriate. In our own teaching experience, projects undertaken in the class facilitate such **exploration** after the students have been **exposed** to the myriad of applications and concepts in the book and they have **experienced** specific software introduced by the professor.



This edition of the book can be used to offer a one-semester overview course on analytics, which covers most or all of the topics/chapters included in the book. It can also be used to teach two consecutive courses. For example, one course could focus on the overall analytics coverage. It could cover selective sections of Chapters 1 and 3–9. A second course could focus on artificial intelligence and emerging technologies as the enablers of modern-day analytics as a subsequent course to the first course. This second course could cover portions of Chapters 1, 2, 6, 9, and 10–14. The book can be used to offer managerial-level exposure to applications and techniques as noted in the previous paragraph, but it also includes sufficient technical details in selected chapters to allow an instructor to focus on some technical methods and hands-on exercises.

Most of the specific improvements made in this eleventh edition concentrate on three areas: reorganization, content update/upgrade (including AI, machine-learning, chatbots, and robotics as enablers of analytics), and a sharper focus. Despite the many changes, we have preserved the comprehensiveness and user friendliness that have made the textbook a market leader in the last several decades. We have also optimized the book's size and content by eliminating older and redundant material and by adding and combining material that is parallel to the current trends and is also demanded by many professors. Finally, we present accurate and updated material that is not available in any other text. We next describe the changes in the eleventh edition.

The book is supported by a Web site ([www.pearsonglobaleditions.com](http://www.pearsonglobaleditions.com)). We provide links to additional learning materials and software tutorials through a special section of the book Web site.

## WHAT'S NEW IN THE ELEVENTH EDITION?

With the goal of improving the text and making it current with the evolving technology trends, this edition marks a major reorganization to better reflect on the current focus on analytics and its enabling technologies. The last three editions transformed the book from the traditional DSS to BI and then from BI to BA and fostered a tight linkage with the Teradata University Network (TUN). This edition is enhanced with new materials paralleling the latest trends in analytics including AI, machine learning, deep learning, robotics, IoT, and smart/robo-collaborative assisting systems and applications. The following summarizes the major changes made to this edition.

- ***New organization.*** The book is now organized around two main themes: (1) presentation of motivations, concepts, methods, and methodologies for different types of analytics (focusing heavily on predictive and prescriptive analytic), and (2) introduction and due coverage of new technology trends as the enablers of the modern-day analytics such as AI, machine learning, deep learning, robotics, IoT, smart/robo-collaborative assisting systems, etc. Chapter 1 provides an introduction to the journey of decision support and enabling technologies. It begins with a brief overview of the classical decision making and decision support systems. Then it moves to business intelligence, followed by an introduction to analytics, Big Data, and AI. We follow that with a deeper introduction to artificial intelligence in Chapter 2. Because data is fundamental to any analysis, Chapter 3 introduces data issues as well as descriptive analytics including statistical concepts and visualization. An online chapter covers data warehousing processes and fundamentals for those who like to dig deeper into these issues. The next section covers predictive analytics and machine learning. Chapter 4 provides an introduction to data mining applications and the data mining process. Chapter 5 introduces many of the common data mining techniques: classification, clustering, association mining, and so forth. Chapter 6 includes coverage of deep learning and cognitive computing. Chapter 7 focuses on

text mining applications as well as Web analytics, including social media analytics, sentiment analysis, and other related topics. The following section brings the “data science” angle to a further depth. Chapter 8 covers prescriptive analytics including optimization and simulation. Chapter 9 includes more details of Big Data analytics. It also includes introduction to cloud-based analytics as well as location analytics. The next section covers Robotics, social networks, AI, and the Internet of Things (IoT). Chapter 10 introduces robots in business and consumer applications and also studies the future impact of such devices on society. Chapter 11 focuses on collaboration systems, crowdsourcing, and social networks. Chapter 12 reviews personal assistants, chatbots, and the exciting developments in this space. Chapter 13 studies IoT and its potential in decision support and a smarter society. The ubiquity of wireless and GPS devices and other sensors is resulting in the creation of massive new databases and unique applications. Finally, Chapter 14 concludes with a brief discussion of security, privacy, and societal dimensions of analytics and AI.

We should note that several chapters included in this edition have been available in the following companion book: *Business Intelligence, Analytics, and Data Science: A Managerial Perspective*, 4th Edition, Pearson (2018) (Hereafter referred to as BI4e). The structure and contents of these chapters have been updated somewhat before inclusion in this edition of the book, but the changes are more significant in the chapters marked as new. Of course, several of the chapters that came from BI4e were not included in previous editions of this book.

- **New chapters.** The following chapters have been added:

**Chapter 2 “Artificial Intelligence: Concepts, Drivers, Major Technologies, and Business Applications”** This chapter covers the essentials of AI, outlines its benefits, compares it with humans’ intelligence, and describes the content of the field. Example applications in accounting, finance, human resource management, marketing and CRM, and production-operation management illustrate the benefits to business (100% new material)

**Chapter 6, “Deep Learning and Cognitive Computing”** This chapter covers the generation of machine learning technique, deep learning as well as the increasingly more popular AI topic, cognitive computing. It is an almost entirely new chapter (90% new material).

**Chapter 10, “Robotics: Industrial and Consumer Applications”** This chapter introduces many robotics applications in industry and for consumers and concludes with impacts of such advances on jobs and some legal ramifications (100% new material).

**Chapter 12, “Knowledge Systems: Expert Systems, Recommenders, Chatbots, Virtual Personal Assistants, and Robo Advisors”** This new chapter concentrates on different types of knowledge systems. Specifically, we cover new generations of expert systems and recommenders, chatbots, enterprise chatbots, virtual personal assistants, and robo-advisors (95% new).

**Chapter 13, “The Internet of Things as a Platform for Intelligent Applications”** This new chapter introduces IoT as an enabler to analytics and AI applications. The following technologies are described in detail: smart homes and appliances, smart cities (including factories), and autonomous vehicles (100% new).

**Chapter 14, “Implementation Issues: From Ethics and Privacy to Organizational and Societal Impacts”** This mostly new chapter deals with implementation issues of intelligent systems (including analytics). The major issues covered are protection of privacy, intellectual property, ethics, technical issues (e.g., integration and security) and administrative issues. We also cover the impact of these technologies on organizations and people and specifically deal with the impact on work and

jobs. Special attention is given to possible unintended impacts of analytics and AI (robots). Then we look at relevant technology trends and conclude with an assessment of the future of analytics and AI (85% new).

- **Streamlined coverage.** We have optimized the book size and content by adding a lot of new material to cover new and cutting-edge analytics and AI trends and technologies while eliminating most of the older, less-used material. We use a dedicated Web site for the textbook to provide some of the older material as well as updated content and links.
- **Revised and updated content.** Several chapters have new opening vignettes that are based on recent stories and events. In addition, application cases throughout the book are new or have been updated to include recent examples of applications of a specific technique/model. These application case stories now include suggested questions for discussion to encourage class discussion as well as further exploration of the specific case and related materials. New Web site links have been added throughout the book. We also deleted many older product links and references. Finally, most chapters have new exercises, Internet assignments, and discussion questions throughout. The specific changes made to each chapter are as follows: Chapters 1, 3–5, and 7–9 borrow material from BI4e to a significant degree.

**Chapter 1, “Overview of Business Intelligence, Analytics, Data Science, and Artificial Intelligence: Systems for Decision Support”** This chapter includes some material from DSS10e Chapters 1 and 2, but includes several new application cases, entirely new material on AI, and of course, a new plan for the book (about 50% new material).

**Chapter 3, “Nature of Data, Statistical Modeling, and Visualization”**

- 75% new content.
- Most of the content related to nature of data and statistical analysis is new.
- New opening case.
- Mostly new cases throughout.

**Chapter 4, “Data Mining Process, Methods, and Algorithms”**

- 25% of the material is new.
- Some of the application cases are new.

**Chapter 5, “Machine Learning Techniques for Predictive Analytics”**

- 40% of the material is new.
- New machine-learning methods: naïve Bayes, Bayesian networks, and ensemble modeling.
- Most of the cases are new.

**Chapter 7, “Text Mining, Sentiment Analysis, and Social Analytics”**

- 25% of the material is new.
- Some of the cases are new.

**Chapter 8, “Prescriptive Analytics: Optimization and Simulation”**

- Several new optimization application exercises are included.
- A new application case is included.
- 20% of the material is new.

**Chapter 9, “Big Data, Cloud Computing, and Location Analytics: Concepts and Tools”** This material has been updated substantially in this chapter to include greater coverage of stream analytics. It also updates material from Chapters 7 and 8 from BI4e (50% new material).

**Chapter 11, “Group Decision Making, Collaborative Systems, and AI Support”** The chapter is completely revised, regrouping group decision support. New topics include

collective and collaborative intelligence, crowdsourcing, swarm AI, and AI support of all related activities (80% new material).

We have retained many of the enhancements made in the last editions and updated the content. These are summarized next:

- **Links to Teradata University Network (TUN).** Most chapters include new links to TUN ([teradatauniversitynetwork.com](http://teradatauniversitynetwork.com)). We encourage the instructors to register and join [teradatauniversitynetwork.com](http://teradatauniversitynetwork.com) and explore the various content available through the site. The cases, white papers, and software exercises available through TUN will keep your class fresh and timely.
- **Book title.** As is already evident, the book's title and focus have changed.
- **Software support.** The TUN Web site provides software support at no charge. It also provides links to free data mining and other software. In addition, the site provides exercises in the use of such software.

## THE SUPPLEMENT PACKAGE: [WWW.PEARSONGLOBALEDITIONS.COM](http://WWW.PEARSONGLOBALEDITIONS.COM)

A comprehensive and flexible technology-support package is available to enhance the teaching and learning experience. The following instructor and student supplements are available on the book's Web site, [www.pearsonglobaleditions.com](http://www.pearsonglobaleditions.com):

- **Instructor's Manual.** The Instructor's Manual includes learning objectives for the entire course and for each chapter, answers to the questions and exercises at the end of each chapter, and teaching suggestions (including instructions for projects). The Instructor's Manual is available on the secure faculty section of [www.pearsonglobaleditions.com](http://www.pearsonglobaleditions.com)
- **Test Item File and TestGen Software.** The Test Item File is a comprehensive collection of true/false, multiple-choice, fill-in-the-blank, and essay questions. The questions are rated by difficulty level, and the answers are referenced by book page number. The Test Item File is available in Microsoft Word and in TestGen. Pearson Education's test-generating software is available from [www.pearsonglobaleditions.com](http://www.pearsonglobaleditions.com). The software is PC/MAC compatible and preloaded with all of the Test Item File questions. You can manually or randomly view test questions and drag-and-drop to create a test. You can add or modify test-bank questions as needed. Our TestGens are converted for use in BlackBoard, WebCT, Moodle, D2L, and Angel. These conversions can be found on [www.pearsonglobaleditions.com](http://www.pearsonglobaleditions.com). The TestGen is also available in Respondus and can be found on [www.respondus.com](http://www.respondus.com).
- **PowerPoint slides.** PowerPoint slides are available that illuminate and build on key concepts in the text. Faculty can download the PowerPoint slides from [www.pearsonglobaleditions.com](http://www.pearsonglobaleditions.com).

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George Federman, Santa Clara City College  
Jerry Fjermestad, New Jersey Institute of Technology  
Joey George, Florida State University  
Paul Gray, Claremont Graduate School  
Orv Greynholds, Capital College (Laurel, Maryland)  
Martin Grossman, Bridgewater State College  
Ray Jacobs, Ashland University  
Leonard Jessup, Indiana University  
Jeffrey Johnson, Utah State University  
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Hank Lucas, New York University  
Jane Mackay, Texas Christian University  
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Benjamin Mittman, Northwestern University  
Larry Moore, Virginia Polytechnic Institute and State University  
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Peter Mykytyn, Southern Illinois University  
Natalie Nazarenko, SUNY College at Fredonia  
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Souren Paul, Southern Illinois University  
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David Russell, Western New England College  
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Meenu Singh, Murray State University  
Randy Smith, University of Virginia