Contents

List of Abbreviations LXI

Part A Development and Impacts of Automation

1 **Advances in Robotics and Automation: Historical Perspectives**
Yukio Hasegawa 3
References 4

2 **Advances in Industrial Automation: Historical Perspectives**
Theodore J. Williams 5
References 11

3 **Automation: What It Means to Us Around the World**
Shimon Y. Nof 13
3.1 The Meaning of Automation 14
3.2 Brief History of Automation 26
3.3 Automation Cases 28
3.4 Flexibility, Degrees, and Levels of Automation 39
3.5 Worldwide Surveys: What Does Automation Mean to People? 43
3.6 Emerging Trends 47
3.7 Conclusion 51
3.8 Further Reading 51
References 52

4 **A History of Automatic Control**
Christopher Bissell 53
4.1 Antiquity and the Early Modern Period 53
4.2 Stability Analysis in the 19th Century 56
4.3 Ship, Aircraft and Industrial Control Before WWII 57
4.4 Electronics, Feedback and Mathematical Analysis 59
4.5 WWII and *Classical* Control: Infrastructure 60
4.6 WWII and *Classical* Control: Theory 62
4.7 The Emergence of *Modern* Control Theory 63
4.8 The Digital Computer 64
4.9 The Socio-Technological Context Since 1945 65
4.10 Conclusion and Emerging Trends 66
4.11 Further Reading 67
References 67

Bibliografische Informationen
http://d-nb.info/992145562

digitalisiert durch DEUTSCHE NATIONAL BIBLIOTHEK

5 **Social, Organizational, and Individual Impacts of Automation**
Tibor Vámos 71
5.1 Scope of Discussion:
Long and Short Range of Man–Machine Systems 72
5.2 Short History 74
5.3 Channels of Human Impact 75
5.4 Change in Human Values 76
5.5 Social Stratification, Increased Gaps 78
5.6 Production, Economy Structures, and Adaptation 81
5.7 Education 86
5.8 Cultural Aspects 88
5.9 Legal Aspects, Ethics, Standards, and Patents 88
5.10 Different Media and Applications of Information Automation 90
5.11 Social Philosophy and Globalization 91
5.12 Further Reading 91
References 92

6 **Economic Aspects of Automation**
Piercarlo Ravazzi, Agostino Villa 93
6.1 Basic Concepts in Evaluating Automation Effects 96
6.2 The Evaluation Model 97
6.3 Effects of Automation in the Enterprise 98
6.4 Mid-Term Effects of Automation 102
6.5 Final Comments 111
6.6 Capital/Labor and Capital/Product Ratios
in the Most Important Italian Industrial Sectors 113
References 115

7 **Impacts of Automation on Precision**
Alkan Donmez, Johannes A. Soons 117
7.1 What Is Precision? 117
7.2 Precision as an Enabler of Automation 118
7.3 Automation as an Enabler of Precision 119
7.4 Cost and Benefits of Precision 119
7.5 Measures of Precision 120
7.6 Factors That Affect Precision 120
7.7 Specific Examples and Applications in Discrete Part Manufacturing .. 121
7.8 Conclusions and Future Trends 124
References 125

8 **Trends in Automation**
Peter Terwiesch, Christopher Ganz 127
8.1 Environment 128
8.2 Current Trends 130
8.3 Outlook 140
8.4 Summary 142
References 142

Part B Automation Theory and Scientific Foundations

9 **Control Theory for Automation: Fundamentals**
Alberto Isidori 147
9.1 Autonomous Dynamical Systems 148
9.2 Stability and Related Concepts 150
9.3 Asymptotic Behavior 153
9.4 Dynamical Systems with Inputs 154
9.5 Feedback Stabilization of Linear Systems 160
9.6 Feedback Stabilization of Nonlinear Systems 163
9.7 Tracking and Regulation 169
9.8 Conclusion 172
References 172

10 **Control Theory for Automation – Advanced Techniques**
István Vajk, Jenő Hetthéssy, Ruth Bars 173
10.1 MIMO Feedback Systems 173
10.2 All Stabilizing Controllers 176
10.3 Control Performances 181
10.4 H_2 Optimal Control 183
10.5 H_∞ Optimal Control 185
10.6 Robust Stability and Performance 186
10.7 General Optimal Control Theory 189
10.8 Model-Based Predictive Control 191
10.9 Control of Nonlinear Systems 193
10.10 Summary 196
References 197

11 **Control of Uncertain Systems**
Jianming Lian, Stanislaw H. Żak 199
11.1 Background and Overview 200
11.2 Plant Model and Notation 203
11.3 Variable-Structure Neural Component 203
11.4 State Feedback Controller Development 209
11.5 Output Feedback Controller Construction 211
11.6 Examples 213
11.7 Summary 216
References 217

12 **Cybernetics and Learning Automata**
John Oommen, Sudip Misra 221
12.1 Basics 221
12.2 A Learning Automaton 223
12.3 Environment 223
12.4 Classification of Learning Automata 224
12.5 Estimator Algorithms 228
12.6 Experiments and Application Examples 232

12.7 Emerging Trends and Open Challenges 233
12.8 Conclusions 234
References 234

13 **Communication in Automation, Including Networking and Wireless**
Nicholas Kottenstette, Panos J. Antsaklis 237
13.1 Basic Considerations 237
13.2 Digital Communication Fundamentals 238
13.3 Networked Systems Communication Limitations 241
13.4 Networked Control Systems 242
13.5 Discussion and Future Research Directions 245
13.6 Conclusions 246
13.7 Appendix 246
References 247

14 **Artificial Intelligence and Automation**
Dana S. Nau 249
14.1 Methods and Application Examples 250
14.2 Emerging Trends and Open Challenges 266
References 266

15 **Virtual Reality and Automation**
P. Pat Banerjee 269
15.1 Overview of Virtual Reality and Automation Technologies 269
15.2 Production/Service Applications 271
15.3 Medical Applications 273
15.4 Conclusions and Emerging Trends 276
References 277

16 **Automation of Mobility and Navigation**
Anibal Ollero, Ángel R. Castaño 279
16.1 Historical Background 279
16.2 Basic Concepts 280
16.3 Vehicle Motion Control 283
16.4 Navigation Control and Interaction with the Environment 285
16.5 Human Interaction 288
16.6 Multiple Mobile Systems 290
16.7 Conclusions 292
References 292

17 **The Human Role in Automation**
Daniel W. Repperger, Chandler A. Phillips 295
17.1 Some Basics of Human Interaction with Automation 296
17.2 Various Application Areas 297

17.3 Modern Key Issues to Consider as Humans Interact with Automation 299
17.4 Future Directions of Defining Human–Machine Interactions 301
17.5 Conclusions 302
References 302

18 **What Can Be Automated? What Cannot Be Automated?**
Richard D. Patton, Peter C. Patton 305
18.1 The Limits of Automation 305
18.2 The Limits of Mechanization 306
18.3 Expanding the Limit 309
18.4 The Current State of the Art 311
18.5 A General Principle 312
References 313

Part C Automation Design: Theory, Elements, and Methods

19 **Mechatronic Systems – A Short Introduction**
Rolf Isermann 317
19.1 From Mechanical to Mechatronic Systems 317
19.2 Mechanical Systems and Mechatronic Developments 319
19.3 Functions of Mechatronic Systems 321
19.4 Integration Forms of Processes with Electronics 323
19.5 Design Procedures for Mechatronic Systems 325
19.6 Computer-Aided Design of Mechatronic Systems 328
19.7 Conclusion and Emerging Trends 329
References 329

20 **Sensors and Sensor Networks**
Wootae Jeong 333
20.1 Sensors 333
20.2 Sensor Networks 338
20.3 Emerging Trends 346
References 347

21 **Industrial Intelligent Robots**
Yoshiharu Inaba, Shinsuke Sakakibara 349
21.1 Current Status of the Industrial Robot Market 349
21.2 Background of the Emergence of Intelligent Robots 350
21.3 Intelligent Robots 352
21.4 Application of Intelligent Robots 359
21.5 Guidelines for Installing Intelligent Robots 362
21.6 Mobile Robots 362
21.7 Conclusion 363
21.8 Further Reading 363
References 363

22 **Modeling and Software for Automation**
Alessandro Pasetti, Walter Schaufelberger (△) 365
22.1 Model-Driven Versus Reuse-Driven Software Development 366
22.2 Model-Driven Software Development 368
22.3 Reuse-Driven Software Development 371
22.4 Current Research Directions 376
22.5 Conclusions and Emerging Trends 379
References 379

23 **Real-Time Autonomic Automation**
Christian Dannegger 381
23.1 Theory 382
23.2 Application Example: Modular Production Machine Control 385
23.3 Application Example: Dynamic Transportation Optimization 391
23.4 How to Design Agent-Oriented Solutions for Autonomic Automation 402
23.5 Emerging Trends and Challenges 402
References 404

24 **Automation Under Service-Oriented Grids**
Jackson He, Enrique Castro-Leon 405
24.1 Emergence of Virtual Service-Oriented Grids 406
24.2 Virtualization 406
24.3 Service Orientation 408
24.4 Grid Computing 414
24.5 Summary and Emerging Challenges 414
24.6 Further Reading 415
References 416

25 **Human Factors in Automation Design**
John D. Lee, Bobbie D. Seppelt 417
25.1 Automation Problems 418
25.2 Characteristics of the System and the Automation 422
25.3 Application Examples and Approaches to Automation Design 424
25.4 Future Challenges in Automation Design 429
References 432

26 **Collaborative Human–Automation Decision Making**
Mary L. Cummings, Sylvain Bruni 437
26.1 Background 438
26.2 The Human–Automation Collaboration Taxonomy (HACT) 439
26.3 HACT Application and Guidelines 442
26.4 Conclusion and Open Challenges 445
References 446

27 **Teleoperation**
Luis Basañez, Raúl Suárez 449
27.1 Historical Background and Motivation 450
27.2 General Scheme and Components 451
27.3 Challenges and Solutions 454
27.4 Application Fields 459
27.5 Conclusion and Trends 464
References 465

28 **Distributed Agent Software for Automation**
Francisco P. Maturana, Dan L. Carnahan, Kenwood H. Hall 469
28.1 Composite Curing Background 471
28.2 Industrial Agent Architecture 473
28.3 Building Agents for the Curing System 475
28.4 Autoclave and Thermocouple Agents 477
28.5 Agent-Based Simulation 478
28.6 Composite Curing Results and Recommendations 480
28.7 Conclusions 484
28.8 Further Reading 484
References 485

29 **Evolutionary Techniques for Automation**
Mitsuo Gen, Lin Lin 487
29.1 Evolutionary Techniques 488
29.2 Evolutionary Techniques for Industrial Automation 492
29.3 AGV Dispatching in Manufacturing System 494
29.4 Robot-Based Assembly-Line System 497
29.5 Conclusions and Emerging Trends 501
29.6 Further Reading 501
References 501

30 **Automating Errors and Conflicts Prognostics and Prevention**
Xin W. Chen, Shimon Y. Nof 503
30.1 Definitions 503
30.2 Error Prognostics and Prevention Applications 506
30.3 Conflict Prognostics and Prevention 512
30.4 Integrated Error and Conflict Prognostics and Prevention 513
30.5 Error Recovery and Conflict Resolution 515
30.6 Emerging Trends 520
30.7 Conclusion 521
References 522

Part D Automation Design: Theory and Methods for Integration

31 **Process Automation**
Thomas F. Edgar, Juergen Hahn 529
31.1 Enterprise View of Process Automation 529
31.2 Process Dynamics and Mathematical Models 531
31.3 Regulatory Control 533
31.4 Control System Design 534
31.5 Batch Process Automation 538
31.6 Automation and Process Safety 541
31.7 Emerging Trends 543
31.8 Further Reading 543
References 543

32 **Product Automation**
Friedrich Pinnekamp 545
32.1 Historical Background 545
32.2 Definition of Product Automation 546
32.3 The Functions of Product Automation 546
32.4 Sensors 547
32.5 Control Systems 547
32.6 Actuators 548
32.7 Energy Supply 548
32.8 Information Exchange with Other Systems 548
32.9 Elements for Product Automation 548
32.10 Embedded Systems 554
32.11 Summary and Emerging Trends 557
References 558

33 **Service Automation**
Friedrich Pinnekamp 559
33.1 Definition of Service Automation 559
33.2 Life Cycle of a Plant 559
33.3 Key Tasks and Features of Industrial Service 560
33.4 Real-Time Performance Monitoring 562
33.5 Analysis of Performance 563
33.6 Information Required for Effective and Efficient Service 563
33.7 Logistics Support 566
33.8 Remote Service 567
33.9 Tools for Service Personnel 568
33.10 Emerging Trends: Towards a Fully Automated Service 568
References 569

34 **Integrated Human and Automation Systems**
Dieter Spath, Martin Braun, Wilhelm Bauer 571
34.1 Basics and Definitions 572
34.2 Use of Automation Technology 579

34.3 Design Rules for Automation 585
34.4 Emerging Trends and Prospects for Automation 594
References 596

35 **Machining Lines Automation**
Xavier Delorme, Alexandre Dolgui, Mohamed Essafi, Laurent Linxe, Damien Poyard 599
35.1 Machining Lines 600
35.2 Machining Line Design 603
35.3 Line Balancing 605
35.4 Industrial Case Study 606
35.5 Conclusion and Perspectives 615
References 616

36 **Large-Scale Complex Systems**
Florin-Gheorghe Filip, Kauko Leiviskä 619
36.1 Background and Scope 620
36.2 Methods and Applications 622
36.3 Case Studies 632
36.4 Emerging Trends 634
References 635

37 **Computer-Aided Design, Computer-Aided Engineering, and Visualization**
Gary R. Bertoline, Nathan Hartman, Nicoletta Adamo-Villani 639
37.1 Modern CAD Tools 639
37.2 Geometry Creation Process 640
37.3 Characteristics of the Modern CAD Environment 642
37.4 User Characteristics Related to CAD Systems 643
37.5 Visualization 644
37.6 3-D Animation Production Process 645
References 651

38 **Design Automation for Microelectronics**
Deming Chen 653
38.1 Overview 653
38.2 Techniques of Electronic Design Automation 657
38.3 New Trends and Conclusion 665
References 667

39 **Safety Warnings for Automation**
Mark R. Lehto, Mary F. Lesch, William J. Horrey 671
39.1 Warning Roles 672
39.2 Types of Warnings 676
39.3 Models of Warning Effectiveness 680

39.4 Design Guidelines and Requirements 684
39.5 Challenges and Emerging Trends 690
References 691

Part E Automation Management

40 Economic Rationalization of Automation Projects
José A. Ceroni 699
40.1 General Economic Rationalization Procedure 700
40.2 Alternative Approach to the Rationalization of Automation Projects. 708
40.3 Future Challenges and Emerging Trends in Automation Rationalization 711
40.4 Conclusions 712
References 713

41 Quality of Service (QoS) of Automation
Heinz-Hermann Erbe (△) 715
41.1 Cost-Oriented Automation 718
41.2 Affordable Automation 721
41.3 Energy-Saving Automation 725
41.4 Emerging Trends 728
41.5 Conclusions 731
References 732

42 Reliability, Maintainability, and Safety
Gérard Morel, Jean-François Pétin, Timothy L. Johnson 735
42.1 Definitions 736
42.2 RMS Engineering 738
42.3 Operational Organization and Architecture for RMS 741
42.4 Challenges, Trends, and Open Issues 745
References 746

43 Product Lifecycle Management and Embedded Information Devices
Dimitris Kiritsis 749
43.1 The Concept of Closed-Loop PLM 749
43.2 The Components of a Closed-Loop PLM System 751
43.3 A Development Guide for Your Closed-Loop PLM Solution 755
43.4 Closed-Loop PLM Application 761
43.5 Emerging Trends and Open Challenges 763
References 764

44 Education and Qualification for Control and Automation
Bozenna Pasik-Duncan, Matthew Verleger 767
44.1 The Importance of Automatic Control in the 21st Century 768
44.2 New Challenges for Education 768

44.3 Interdisciplinary Nature of Stochastic Control 769
44.4 New Applications of Systems and Control Theory 770
44.5 Pedagogical Approaches 772
44.6 Integrating Scholarship, Teaching, and Learning 775
44.7 The Scholarship of Teaching and Learning 775
44.8 Conclusions and Emerging Challenges 776
References 776

45 **Software Management**
Peter C. Patton, Bijay K. Jayaswal 779
45.1 Automation and Software Management 779
45.2 Software Distribution 781
45.3 Asset Management 786
45.4 Cost Estimation 789
45.5 Further Reading 794
References 794

46 **Practical Automation Specification**
Wolfgang Mann 797
46.1 Overview 797
46.2 Intention 798
46.3 Strategy 800
46.4 Implementation 803
46.5 Additional Impacts 803
46.6 Example 804
46.7 Conclusion 807
46.8 Further Reading 807
References 808

47 **Automation and Ethics**
Srinivasan Ramaswamy, Hemant Joshi 809
47.1 Background 810
47.2 What Is Ethics, and How Is It Related to Automation? 810
47.3 Dimensions of Ethics 811
47.4 Ethical Analysis and Evaluation Steps 814
47.5 Ethics and STEM Education 817
47.6 Ethics and Research 822
47.7 Challenges and Emerging Trends 825
47.8 Additional Online Resources 826
47.A Appendix: Code of Ethics Example 827
References 831

Part F Industrial Automation

48 **Machine Tool Automation**
Keiichi Shirase, Susumu Fujii 837
48.1 The Advent of the NC Machine Tool 839
48.2 Development of Machining Center and Turning Center 841
48.3 NC Part Programming 844
48.4 Technical Innovation in NC Machine Tools 847
48.5 Key Technologies for Future Intelligent Machine Tool 856
48.6 Further Reading 857
References 857

49 **Digital Manufacturing and RFID-Based Automation**
Wing B. Lee, Benny C.F. Cheung, Siu K. Kwok 859
49.1 Overview 859
49.2 Digital Manufacturing Based on Virtual Manufacturing (VM) 860
49.3 Digital Manufacturing by RFID-Based Automation 864
49.4 Case Studies of Digital Manufacturing and RFID-Based Automation .. 867
49.5 Conclusions 877
References 878

50 **Flexible and Precision Assembly**
Brian Carlisle 881
50.1 Flexible Assembly Automation 881
50.2 Small Parts 886
50.3 Automation Software Architecture 887
50.4 Conclusions and Future Challenges 890
50.5 Further Reading 890
References 890

51 **Aircraft Manufacturing and Assembly**
Branko Sarh, James Buttrick, Clayton Munk, Richard Bossi 893
51.1 Aircraft Manufacturing and Assembly Background 894
51.2 Automated Part Fabrication Systems: Examples 895
51.3 Automated Part Inspection Systems: Examples 903
51.4 Automated Assembly Systems/Examples 905
51.5 Concluding Remarks and Emerging Trends 908
References 909

52 **Semiconductor Manufacturing Automation**
Tae-Eog Lee 911
52.1 Historical Background 911
52.2 Semiconductor Manufacturing Systems and Automation Requirements 912
52.3 Equipment Integration Architecture and Control 914
52.4 Fab Integration Architectures and Operation 921

52.5 Conclusion 925
References 925

53 **Nanomanufacturing Automation**
Ning Xi, King Wai Chiu Lai, Heping Chen 927
53.1 Overview 927
53.2 AFM-Based Nanomanufacturing 930
53.3 Nanomanufacturing Processes 937
53.4 Conclusions 944
References 944

54 **Production, Supply, Logistics and Distribution**
Rodrigo J. Cruz Di Palma, Manuel Scavarda Basaldúa 947
54.1 Historical Background 947
54.2 Machines and Equipment Automation for Production 949
54.3 Computing and Communication Automation for Planning and Operations Decisions 951
54.4 Automation Design Strategy 954
54.5 Emerging Trends and Challenges 955
54.6 Further Reading 958
References 959

55 **Material Handling Automation in Production and Warehouse Systems**
Jaewoo Chung, Jose M.A. Tanchoco 961
55.1 Material Handling Integration 962
55.2 System Architecture 964
55.3 Advanced Technologies 969
55.4 Conclusions and Emerging Trends 977
References 977

56 **Industrial Communication Protocols**
Carlos E. Pereira, Peter Neumann 981
56.1 Basic Information 981
56.2 Virtual Automation Networks 983
56.3 Wired Industrial Communications 984
56.4 Wireless Industrial Communications 991
56.5 Wide Area Communications 993
56.6 Conclusions 995
56.7 Emerging Trends 995
56.8 Further Reading 997
References 998

57 **Automation and Robotics in Mining and Mineral Processing**
Sirkka-Liisa Jämsä-Jounela, Greg Baiden 1001
57.1 Background 1001
57.2 Mining Methods and Application Examples 1004

57.3 Processing Methods and Application Examples 1005
57.4 Emerging Trends 1009
References 1012

58 **Automation in the Wood and Paper Industry**
Birgit Vogel-Heuser 1015
58.1 Background Development and Theory 1015
58.2 Application Example, Guidelines, and Techniques 1018
58.3 Emerging Trends, Open Challenges 1024
References 1025

59 **Welding Automation**
Anatol Pashkevich 1027
59.1 Principal Definitions 1027
59.2 Welding Processes 1028
59.3 Basic Equipment and Control Parameters 1031
59.4 Welding Process Sensing, Monitoring, and Control 1033
59.5 Robotic Welding 1035
59.6 Future Trends in Automated Welding 1038
59.7 Further Reading 1039
References 1039

60 **Automation in Food Processing**
Darwin G. Caldwell, Steve Davis, René J. Moreno Masey, John O. Gray 1041
60.1 The Food Industry 1042
60.2 Generic Considerations in Automation for Food Processing 1043
60.3 Packaging, Palletizing, and Mixed Pallet Automation 1046
60.4 Raw Product Handling and Assembly 1049
60.5 Decorative Product Finishing 1054
60.6 Assembly of Food Products – Making a Sandwich 1055
60.7 Discrete Event Simulation Example 1056
60.8 Totally Integrated Automation 1057
60.9 Conclusions 1058
60.10 Further Reading 1058
References 1058

Part G Infrastructure and Service Automation

61 **Construction Automation**
Daniel Castro-Lacouture 1063
61.1 Motivations for Automating Construction Operations 1064
61.2 Background 1065
61.3 Horizontal Construction Automation 1066
61.4 Building Construction Automation 1068
61.5 Techniques and Guidelines for Construction Management Automation 1070

61.6 Application Examples 1073
61.7 Conclusions and Challenges 1076
References 1076

62 **The Smart Building**
Timothy I. Salsbury 1079
62.1 Background 1079
62.2 Application Examples 1083
62.3 Emerging Trends 1088
62.4 Open Challenges 1090
62.5 Conclusions 1092
References 1092

63 **Automation in Agriculture**
Yael Edan, Shufeng Han, Naoshi Kondo 1095
63.1 Field Machinery 1096
63.2 Irrigation Systems 1101
63.3 Greenhouse Automation 1104
63.4 Animal Automation Systems 1111
63.5 Fruit Production Operations 1116
63.6 Summary 1121
References 1122

64 **Control System for Automated Feed Plant**
Nick A. Ivanescu 1129
64.1 Objectives 1129
64.2 Problem Description 1130
64.3 Special Issues To Be Solved 1131
64.4 Choosing the Control System 1131
64.5 Calibrating the Weighing Machines 1132
64.6 Management of the Extraction Process 1133
64.7 Software Design: Theory and Application 1133
64.8 Communication 1136
64.9 Graphical User Interface on the PLC 1136
64.10 Automatic Feeding of Chicken 1137
64.11 Environment Control in the Chicken Plant 1137
64.12 Results and Conclusions 1138
64.13 Further Reading 1138
References 1138

65 **Securing Electrical Power System Operation**
Petr Horacek 1139
65.1 Power Balancing 1141
65.2 Ancillary Services Planning 1153
References 1162

66 **Vehicle and Road Automation**
Yuko J. Nakanishi 1165
66.1 Background 1165
66.2 Integrated Vehicle-Based Safety Systems (IVBSS) 1171
66.3 Vehicle Infrastructure Integration (VII) 1176
66.4 Conclusion and Emerging Trends 1177
66.5 Further Reading 1178
References 1180

67 **Air Transportation System Automation**
Satish C. Mohleji, Dean F. Lamiano, Sebastian V. Massimini 1181
67.1 Current NAS CNS/ATM Systems Infrastructure 1183
67.2 Functional Role of Automation in Aircraft for Flight Safety and Efficiency 1194
67.3 Functional Role of Automation in the Ground System for Flight Safety and Efficiency 1195
67.4 CNS/ATM Functional Limitations with Impact on Operational Performance Measures 1196
67.5 Future Air Transportation System Requirements and Functional Automation 1203
67.6 Summary 1211
References 1212

68 **Flight Deck Automation**
Steven J. Landry 1215
68.1 Background and Theory 1215
68.2 Application Examples 1217
68.3 Guidelines for Automation Development 1226
68.4 Flight Deck Automation in the Next-Generation Air-Traffic System .. 1234
68.5 Conclusion 1236
68.6 Web Resources 1236
References 1237

69 **Space and Exploration Automation**
Edward Tunstel 1241
69.1 Space Automation/Robotics Background 1242
69.2 Challenges of Space Automation 1243
69.3 Past and Present Space Robots and Applications 1248
69.4 Future Directions and Capability Needs 1250
69.5 Summary and Conclusion 1251
69.6 Further Reading 1251
References 1252

70 **Cleaning Automation**
Norbert Elkmann, Justus Hortig, Markus Fritzsche 1253
70.1 Background and Cleaning Automation Theory 1254
70.2 Examples of Application 1256

70.3 Emerging Trends 1263
References 1263

71 **Automating Information and Technology Services**
Parasuram Balasubramanian 1265
71.1 Preamble 1265
71.2 Distinct Business Segments 1267
71.3 Automation Path in Each Business Segment 1269
71.4 Information Technology Services 1274
71.5 Impact Analysis 1281
71.6 Emerging Trends 1282
References 1282

72 **Library Automation**
Michael Kaplan 1285
72.1 In the Beginning: Book Catalogs and Card Catalogs 1285
72.2 Development of the MARC Format and Online Bibliographic Utilities 1286
72.3 OpenURL Linking and the Rise of Link Resolvers 1290
72.4 Future Challenges 1296
72.5 Further Reading 1296
References 1297

73 **Automating Serious Games**
Gyula Vastag, Moshe Yerushalmy 1299
73.1 Theoretical Foundation and Developments: Learning Through Gaming 1299
73.2 Application Examples 1303
73.3 Guidelines and Techniques for Serious Games 1306
73.4 Emerging Trends, Open Challenges 1309
73.5 Additional Reading 1310
References 1310

74 **Automation in Sports and Entertainment**
Peter Kopacek 1313
74.1 Robots in Entertainment, Leisure, and Hobby 1315
74.2 Market 1330
74.3 Summary and Forecast 1330
74.4 Further Reading 1331
References 1331

Part H Automation in Medical and Healthcare Systems

75 **Automatic Control in Systems Biology**
Henry Mirsky, Jörg Stelling, Rudiyanto Gunawan, Neda Bagheri, Stephanie R. Taylor, Eric Kwei, Jason E. Shoemaker, Francis J. Doyle III 1335
75.1 Basics 1335

75.2 Biophysical Networks 1337
75.3 Network Models for Structural Classification 1340
75.4 Dynamical Models 1342
75.5 Network Identification 1346
75.6 Quantitative Performance Metrics 1349
75.7 Bio-inspired Control and Design 1353
75.8 Emerging Trends 1354
References 1354

76 **Automation and Control in Biomedical Systems**
Robert S. Parker 1361
76.1 Background and Introduction 1361
76.2 Theory and Tools 1364
76.3 Techniques and Applications 1369
76.4 Emerging Areas and Challenges 1373
76.5 Summary 1375
References 1375

77 **Automation in Hospitals and Healthcare**
Brandon Savage 1379
77.1 The Need for Automation in Healthcare 1380
77.2 The Role of Medical Informatics 1382
77.3 Applications 1389
77.4 Conclusion 1396
References 1396

78 **Medical Automation and Robotics**
Alon Wolf, Moshe Shoham 1397
78.1 Classification of Medical Robotics Systems 1398
78.2 Kinematic Structure of Medical Robots 1403
78.3 Fundamental Requirements from a Medical Robot 1404
78.4 Main Advantages of Medical Robotic Systems 1404
78.5 Emerging Trends in Medical Robotics Systems 1405
References 1406

79 **Rotary Heart Assist Devices**
Marwan A. Simaan 1409
79.1 The Cardiovascular Model 1410
79.2 Cardiovascular Model Validation 1414
79.3 LVAD Pump Model 1415
79.4 Combined Cardiovascular and LVAD Model 1416
79.5 Challenges in the Development of a Feedback Controller and Suction Detection Algorithm 1418
79.6 Conclusion 1420
References 1420

80 **Medical Informatics**
Chin-Yin Huang 1423
80.1 Background 1423
80.2 Diagnostic–Therapeutic Cycle 1424
80.3 Communication and Integration 1425
80.4 Database and Data Warehouse 1426
80.5 Medical Support Systems 1427
80.6 Medical Knowledge and Decision Support System 1429
80.7 Developing a Healthcare Information System 1430
80.8 Emerging Issues 1431
References 1432

81 **Nanoelectronic-Based Detection for Biology and Medicine**
Samir M. Iqbal, Rashid Bashir 1433
81.1 Historical Background 1433
81.2 Interfacing Biological Molecules 1434
81.3 Electrical Characterization of DNA Molecules on Surfaces 1438
81.4 Nanopore Sensors for Characterization of Single DNA Molecules 1441
81.5 Conclusions and Outlook 1447
References 1447

82 **Computer and Robot-Assisted Medical Intervention**
Jocelyne Troccaz 1451
82.1 Clinical Context and Objectives 1451
82.2 Computer-Assisted Medical Intervention 1452
82.3 Main Periods of Medical Robot Development 1454
82.4 Evolution of Control Schemes 1458
82.5 The Cyberknife System: A Case Study 1459
82.6 Specific Issues in Medical Robotics 1461
82.7 Systems Used in Clinical Practice 1462
82.8 Conclusions and Emerging Trends 1463
82.9 Medical Glossary 1463
References 1464

Part I Home, Office, and Enterprise Automation

83 **Automation in Home Appliances**
T. Joseph Lui 1469
83.1 Background and Theory 1469
83.2 Application Examples, Guidelines, and Techniques 1472
83.3 Emerging Trends and Open Challenges 1481
83.4 Further Reading 1483
References 1483

84 **Service Robots and Automation for the Disabled/Limited**
Birgit Graf, Harald Staab 1485
84.1 Motivation and Required Functionalities 1486

84.2 State of the Art 1486
84.3 Application Example: the Robotic Home Assistant Care-O-bot 1493
84.4 Application Example: the Bionic Robotic Arm ISELLA 1496
84.5 Future Challenges 1499
References 1499

85 **Automation in Education/Learning Systems**
Kazuyoshi Ishii, Kinnya Tamaki 1503
85.1 Technology Aspects of Education/Learning Systems 1503
85.2 Examples 1511
85.3 Conclusions and Emerging Trends 1523
References 1524

86 **Enterprise Integration and Interoperability**
François B. Vernadat 1529
86.1 Definitions and Background 1530
86.2 Integration and Interoperability Frameworks 1532
86.3 Standards and Technology for Interoperability 1533
86.4 Applications and Future Trends 1535
86.5 Conclusion 1537
References 1537

87 **Decision Support Systems**
Daniel J. Power, Ramesh Sharda 1539
87.1 Characteristics of DSS 1540
87.2 Building Decision Support Systems 1544
87.3 DSS Architecture 1546
87.4 Conclusions 1547
87.5 Further Reading 1547
References 1548

88 **Collaborative e-Work, e-Business, and e-Service**
Juan D. Velásquez, Shimon Y. Nof 1549
88.1 Background and Definitions 1549
88.2 Theoretical Foundations of e-Work and Collaborative Control Theory (CCT) 1552
88.3 Design Principles for Collaborative e-Work, e-Business, and e-Service 1562
88.4 Conclusions and Challenges 1571
88.5 Further Reading 1572
References 1573

89 **e-Commerce**
Clyde W. Holsapple, Sharath Sasidharan 1577
89.1 Background 1578
89.2 Theory 1580
89.3 e-Commerce Models and Applications 1585

89.4 Emerging Trends in e-Commerce 1591
89.5 Challenges and Emerging Issues in e-Commerce 1592
References 1594

90 **Business Process Automation**
Edward F. Watson, Karyn Holmes 1597
90.1 Definitions and Background 1598
90.2 Enterprise Systems Application Frameworks 1606
90.3 Emerging Standards and Technology 1609
90.4 Future Trends 1610
90.5 Conclusion 1611
References 1611

91 **Automation in Financial Services**
William Richmond 1613
91.1 Overview of the Financial Service Industry 1614
91.2 Community Banks and Credit Unions 1616
91.3 Role of Automation in Community Banks and Credit Unions 1619
91.4 Emerging Trends and Issues 1625
91.5 Conclusions 1626
References 1626

92 **e-Government**
Dieter Rombach, Petra Steffens 1629
92.1 Automating Administrative Processes 1629
92.2 The Evolution of e-Government 1630
92.3 Proceeding from Strategy to Roll-Out: Four Dimensions of Action 1633
92.4 Future Challenges in e-Government Automation 1639
References 1641

93 **Collaborative Analytics for Astrophysics Explorations**
Cecilia R. Aragon 1645
93.1 Scope 1645
93.2 Science Background 1646
93.3 Previous Work 1648
93.4 Sunfall Design Process 1649
93.5 Sunfall Architecture and Components 1650
93.6 Conclusions 1666
References 1668

Part J Appendix

94 **Automation Statistics**
Juan D. Velásquez, Xin W. Chen, Sang Won Yoon, Hoo Sang Ko 1673
94.1 Automation Statistics 1674
94.2 Automation Associations 1685

94.3 Automation Laboratories Around the World 1693
94.4 Automation Journals from Around the World 1696

Acknowledgements 1703
About the Authors 1707
Detailed Contents 1735
Subject Index 1777