Contents

Part I Basics

1 Introduction . . . 3
1.1 About This Chapter . . . 3
1.2 General Aspects . . . 3
1.2.1 A Bit of the History . . . 4
1.3 Intended Readers . . . 6
1.4 Outline of the Book . . . 7
1.4.1 Part I: Basics . . . 7
1.4.2 Part II: Core Methods . . . 9
1.4.3 Part III: Advanced Elements . . . 11
1.4.4 Part IV: Complex Knowledge Sources . . . 12
1.4.5 Part V: Additions . . . 13
1.4.6 Chapter Structure . . . 14
References . . . 15

2 Basic CBR Elements . . . 17
2.1 About This Chapter . . . 17
2.2 General Aspects . . . 17
2.3 Case-Based Reasoning . . . 17
2.4 Experiences and Cases . . . 18
2.4.1 Parts of a Case . . . 20
2.4.2 Problems . . . 21
2.4.3 Solution Types . . . 22
2.5 Case Representations . . . 23
2.5.1 How Cases Are Represented . . . 23
2.6 Case Bases . . . 24
2.6.1 How Are Cases Organised? . . . 25
2.7 Similarity and Retrieval . . . 26
2.8 Reuse and Adaptation . . . 30
2.9 Models of CBR . . . 31
2.9.1 CBR Process Model . . . 32

2.9.2 CBR Knowledge Model . . . 34
2.10 Tools . . . 37
2.11 Chapter Summary . . . 38
2.12 Background Information . . . 38
2.13 Exercises . . . 39
References . . . 40

3 Extended View . . . 41
3.1 About This Chapter . . . 41
3.2 General Aspects . . . 41
3.2.1 E-Commerce . . . 42
3.2.2 Recommender Systems . . . 46
3.3 Extended Model . . . 47
3.4 More Generalizations . . . 49
3.5 Tools . . . 50
3.6 Chapter Summary . . . 51
3.7 Background Information . . . 51
3.8 Exercises . . . 51
References . . . 52

4 Application Examples . . . 53
4.1 About This Chapter . . . 53
4.2 General Aspects . . . 53
4.3 Analytic Tasks . . . 55
4.3.1 Classification . . . 56
4.3.2 Diagnosis . . . 57
4.3.3 Prediction . . . 62
4.4 Synthetic Tasks . . . 64
4.4.1 Configuration . . . 64
4.4.2 Planning . . . 66
4.4.3 Design . . . 69
4.5 Organisation-Oriented Applications . . . 70
4.5.1 Call Centres . . . 70
4.5.2 E-Commerce . . . 72
4.5.3 Knowledge Management . . . 75
4.5.4 Law . . . 78
4.6 Complex Knowledge Sources . . . 80
4.6.1 Texts . . . 80
4.6.2 Images . . . 81
4.7 Chapter Summary . . . 82
4.8 Background Information . . . 82
4.9 Exercises . . . 83
References . . . 84

Part II Core Methods

5 Case Representations . . . 87
5.1 About This Chapter . . . 87
5.2 General Aspects . . . 87
5.2.1 Representation Layers . . . 87
5.2.2 Completeness and Efficiency . . . 92
5.2.3 Flat Attribute-Value Representation . . . 93
5.2.4 Complex Representations in General . . . 95
5.3 Tools . . . 109
5.4 Chapter Summary . . . 110
5.5 Background Information . . . 110
5.6 Exercises . . . 110
References . . . 111

6 Basic Similarity Topics . . . 113
6.1 About This Chapter . . . 113
6.2 General Aspects . . . 113
6.3 Similarity and Case Representations . . . 114
6.3.1 Mathematical Models of Similarity . . . 115
6.3.2 Meaning of Similarity . . . 115
6.4 Types of Similarity Measures . . . 125
6.4.1 Counting Similarities . . . 126
6.4.2 Metric Similarities . . . 129
6.4.3 Comparisons . . . 130
6.4.4 Structured Similarities and Symbolic Arguments . . . 130
6.4.5 Transformational Similarities . . . 133
6.5 The Local-Global Principle for Similarity Measures . . . 133
6.5.1 Weighted Measures . . . 134
6.5.2 Local Measures . . . 135
6.5.3 Global Aspects . . . 138
6.5.4 Weights . . . 138
6.6 Virtual Attributes . . . 141
6.7 Which Similarity Measure Should I Use? . . . 142
6.8 Tools . . . 144
6.9 Chapter Summary . . . 145
6.10 Background Information . . . 145
6.11 Exercises . . . 146
References . . . 147

7 Complex Similarity Topics . . . 149
7.1 About This Chapter . . . 149
7.2 Graph Representations and Graph Similarities . . . 149
7.2.1 Graph Isomorphism . . . 149
7.2.2 Subgraph Isomorphism . . . 150
7.3 Largest Common Subgraphs . . . 150

7.3.1 Edit Operations . . . 151
7.4 Taxonomic Similarities . . . 153
7.5 Similarities for Object-Oriented Representations . . . 156
7.6 Many-Valued Attributes . . . 158
7.7 Similarity for Processes and Workflows . . . 159
7.7.1 Similarities for Time Series . . . 161
7.8 Tools . . . 162
7.9 Chapter Summary . . . 162
7.10 Background Information . . . 163
7.11 Exercises . . . 163
References . . . 164

8 Retrieval . . . 167
8.1 About This Chapter . . . 167
8.2 General Aspects . . . 167
8.3 The Retrieval Task . . . 168
8.3.1 Retrieval Errors . . . 169
8.4 Basic Retrieval Methods . . . 170
8.4.1 Query Generation . . . 170
8.4.2 Filtering . . . 170
8.4.3 Sequential Retrieval . . . 171
8.4.4 Two-Level Retrieval . . . 172
8.4.5 Geometric Methods . . . 173
8.4.6 Voronoi Diagrams and k-Nearest Neighbours . . . 173
8.4.7 Geometric Approximation . . . 175
8.4.8 Geometric Filtering . . . 176
8.4.9 Index-Based Retrieval . . . 177
8.4.10 kd-Trees . . . 178
8.4.11 Integration with Decision Trees . . . 183
8.5 Tools . . . 185
8.6 Chapter Summary . . . 185
8.7 Background Information . . . 185
8.8 Exercises . . . 186
References . . . 186

9 Adaptation . . . 189
9.1 About This Chapter . . . 189
9.2 General Aspects . . . 189
9.3 Rules . . . 191
9.3.1 Preconditions . . . 192
9.3.2 Actions . . . 192
9.3.3 Types of Rules . . . 193
9.3.4 Integrating Completion and Adaptation Rules . . . 197
9.4 Adaptation Types . . . 198
9.5 The Adaptation Process . . . 199
9.5.1 Adaptation Sequences . . . 200

9.5.2 Adaptation Planning . . . 202
9.5.3 Learning Heuristics . . . 209
9.5.4 Adaptation in More Complex Situations . . . 210
9.6 Adaptation Using Several Cases . . . 210
9.6.1 Simple Numerical Adaptations . . . 210
9.7 Adaptations Using the Solution Process . . . 213
9.8 Quality Issues . . . 216
9.9 Knowledge in the Adaptation Container . . . 216
9.10 When Should Adaptation Be Considered? . . . 217
9.11 Tools . . . 217
9.12 Chapter Summary . . . 217
9.13 Background Information . . . 218
9.14 Exercises . . . 218
References . . . 219

10 Evaluation, Revision, and Learning . . . 221
10.1 About This Chapter . . . 221
10.2 General Aspects . . . 221
10.2.1 The Purpose . . . 221
10.2.2 Principal Aspects . . . 221
10.3 Evaluation . . . 223
10.4 Revision . . . 224
10.5 Learning . . . 226
10.5.1 Overfitting and Underfitting . . . 228
10.6 Learning to Fill and Modify Knowledge Containers . . . 229
10.6.1 The Vocabulary Container . . . 229
10.6.2 The Case Base Container . . . 229
10.6.3 The Similarity Container . . . 234
10.6.4 The Adaptation Container . . . 238
10.7 Applying Machine Learning Methods . . . 238
10.7.1 Regression Learning . . . 238
10.7.2 Artificial Neural Networks . . . 239
10.7.3 Genetic Algorithms . . . 239
10.7.4 Reinforcement Learning . . . 241
10.7.5 Clustering Methods . . . 241
10.7.6 Bayesian Learning . . . 242
10.8 Tools . . . 242
10.9 Chapter Summary . . . 243
10.10 Background Information . . . 243
10.11 Exercises . . . 244
References . . . 245

11 Development and Maintenance . . . 247
11.1 About This Chapter . . . 247
11.2 General Aspects . . . 247
11.3 Development . . . 248

11.3.1 Problem Formulation . . . 248
11.3.2 Finding and Getting Data, Preprocessing . . . 250
11.3.3 Case Acquisition . . . 251
11.3.4 Prototypes and Evaluation . . . 251
11.3.5 The Knowledge Containers . . . 252
11.3.6 Which Additional Methods Can a CBR System Have? . 254
11.3.7 Systematic Development of CBR Systems . . . 254
11.3.8 Implementation Aspects . . . 257
11.3.9 Combining CBR with Other Techniques . . . 257
11.4 Maintenance . . . 260
11.4.1 Changed Environment and Techniques . . . 261
11.4.2 Maintenance and Knowledge Containers . . . 263
11.4.3 Systematic System Maintenance . . . 266
11.5 Tools . . . 270
11.6 Chapter Summary . . . 271
11.7 Background Information . . . 271
11.8 Exercises . . . 272
References . . . 272

Part III Advanced Elements

12 Advanced CBR Elements . . . 277
12.1 About This Chapter . . . 277
12.2 Discussion of the Relations Between Containers . . . 277
12.3 Contexts . . . 281
12.3.1 Generalities . . . 281
12.3.2 Different Contexts . . . 282
12.3.3 Contexts and Knowledge Containers . . . 284
12.4 Ontologies . . . 285
12.4.1 Ontologies in CBR . . . 286
12.5 CBR Systems . . . 288
12.5.1 Case Properties . . . 289
12.5.2 Case Base Properties . . . 290
12.5.3 Conditions . . . 291
12.5.4 Correctness and Provenance . . . 293
12.5.5 Distributed Case Bases . . . 295
12.6 Tools . . . 296
12.7 Chapter Summary . . . 296
12.8 Background Information . . . 296
12.9 Exercises . . . 297
References . . . 297

13 Advanced Similarity Topics . . . 299
13.1 About This Chapter . . . 299
13.1.1 Foundations . . . 299
13.1.2 Formal Aspects . . . 300

13.1.3 Meaning and Semantics . . . 300
13.1.4 Subjectivity . . . 303
13.1.5 Discussion of the Axioms for Similarity . . . 306
13.1.6 First- and Second-Order Similarities . . . 308
13.2 Miscellaneous Topics . . . 310
13.2.1 Nonfunctional Aspects . . . 310
13.2.2 Top-Down Versus Bottom-Up . . . 310
13.2.3 Jumps and Noise . . . 312
13.3 Functional Dependency, Unknown and Redundant Values . . . 312
13.3.1 Functional Dependency . . . 312
13.3.2 Unknown Values . . . 313
13.3.3 Redundant Values . . . 313
13.4 Additional Problems . . . 314
13.4.1 Similarity and Explanations . . . 314
13.4.2 Similarity and Logical Inference . . . 314
13.5 The Knowledge Contained in the Measures . . . 315
13.6 Tools . . . 317
13.7 Chapter Summary . . . 317
13.8 Background Information . . . 317
13.9 Exercises . . . 318
References . . . 318

14 Advanced Retrieval . . . 321
14.1 About This Chapter . . . 321
14.2 General Aspects . . . 321
14.2.1 Case Retrieval Nets . . . 321
14.2.2 Fish and Shrink . . . 326
14.2.3 PROTOS: Another Two-Step Retrieval . . . 330
14.2.4 Fuzzy Retrieval . . . 331
14.2.5 Comparison . . . 331
14.2.6 Reducing the Search Space and Preprocessing . . . 331
14.3 Similarity Diversity . . . 334
14.4 Which Retrieval Method Should I Use? . . . 336
14.5 Tools . . . 336
14.6 Chapter Summary . . . 336
14.7 Background Information . . . 337
14.8 Exercises . . . 337
References . . . 338

15 Uncertainty . . . 339
15.1 About This Chapter . . . 339
15.2 General Aspects . . . 339
15.3 Uncertainty Concepts and Methods . . . 340
15.3.1 Rough Sets . . . 340
15.3.2 Fuzzy Sets . . . 342
15.3.3 Basic Elements in Fuzzy Set Theory . . . 344

15.4 Fuzzy Sets and CBR . . . 348
15.4.1 General Relations . . . 348
15.4.2 Fuzzy Cases . . . 348
15.4.3 Similarities . . . 348
15.4.4 Comparisons . . . 350
15.5 Possibility, Necessity, and CBR . . . 352
15.5.1 General . . . 352
15.6 Tools . . . 354
15.7 Chapter Summary . . . 354
15.8 Background Information . . . 355
15.9 Exercises . . . 355
References . . . 355

16 Probabilities . . . 357
16.1 About This Chapter . . . 357
16.2 General Aspects . . . 357
16.2.1 From Probabilities to Measures . . . 358
16.2.2 From Similarities to Probabilities . . . 363
16.3 Bayesian Reasoning . . . 365
16.3.1 Dynamics . . . 366
16.3.2 Using the Nets . . . 368
16.3.3 Stochastic Processes . . . 368
16.4 Tools . . . 370
16.5 Chapter Summary . . . 370
16.6 Background Information . . . 371
16.7 Exercises . . . 371
References . . . 372

Part IV Complex Knowledge Sources

17 Textual CBR . . . 375
17.1 About This Chapter . . . 375
17.2 General . . . 375
17.2.1 Text, Structure, and Levels . . . 376
17.2.2 Text Properties . . . 380
17.2.3 Problems in Understanding Text . . . 382
17.3 The Vocabulary Container . . . 383
17.3.1 Text Processing . . . 384
17.3.2 N-Grams . . . 386
17.3.3 Bag of Words . . . 386
17.3.4 Vector Representations . . . 387
17.3.5 Distributed and Reduced Representations . . . 387
17.3.6 Other Representations . . . 391
17.3.7 Identifying and Enhancing the Vocabulary . . . 391
17.4 The Case Base Container . . . 395
17.4.1 Hypertext . . . 395
17.4.2 Information Extraction . . . 396

17.4.3 Information Entities in Basic Case Retrieval Nets 397
17.5 The Similarity Container 397
17.5.1 Relevance-Oriented Measures 397
17.5.2 Structure-Oriented Similarity Measures 398
17.5.3 Measures for Segments 400
17.5.4 Text to Text Similarity Measures 401
17.6 The Adaptation Container 402
17.7 What Textual CBR Method Should I Use? 403
17.8 Tools 404
17.9 Chapter Summary 405
17.10 Background Information 405
17.11 Exercises 406
References 407

18 Images 411
18.1 About This Chapter 411
18.2 General Aspects 411
18.3 Image Structure 413
18.3.1 Image Levels 413
18.4 The Level Structure 415
18.5 The Image Pixel Level 417
18.5.1 The Geometric Level 418
18.5.2 The Symbolic and Domain-Specific Level 421
18.5.3 The Overall Level 423
18.6 Semantics 425
18.6.1 Aesthetics 428
18.7 Knowledge Containers 431
18.7.1 The Vocabulary Container 431
18.7.2 The Similarity Container 431
18.7.3 The Case Base Container 433
18.7.4 The Adaptation Container 436
18.8 Revision 436
18.9 Standards 436
18.10 How to Design Such a CBR System? 437
18.11 Applications 437
18.12 Tools 438
18.13 Chapter Summary 438
18.14 Background Information 439
18.15 Exercises 440
References 441

19 Sensor Data and Speech 443
19.1 About This Chapter 443
19.2 General Aspects 443
19.3 The Level Structure 445
19.3.1 The Low Level of Signals 446

19.3.2 The Feature Level . . . 447
19.3.3 The Symbolic and the Overall Level . . . 448
19.4 Semantics . . . 449
19.5 Remarks on CBR Process Steps . . . 449
19.5.1 Cases and Case Bases . . . 449
19.5.2 Similarity . . . 450
19.5.3 Retrieval . . . 451
19.6 Speech Recognition . . . 451
19.6.1 The Whole Speech Process . . . 452
19.6.2 The Role of the Levels . . . 453
19.6.3 Structure of a Speech Recognition System . . . 454
19.6.4 Cases and Case Bases . . . 454
19.6.5 Speech Feature Extraction and Similarity . . . 454
19.6.6 The Word Level and the Vocabulary in Speech . . . 456
19.6.7 The Overall Level . . . 456
19.6.8 Semantics . . . 457
19.6.9 Adaptation . . . 457
19.6.10 Errors . . . 458
19.7 Applications . . . 459
19.7.1 Diagnosis . . . 459
19.7.2 Speech Applications . . . 459
19.7.3 Conversational CBR . . . 460
19.8 Tools . . . 460
19.9 Chapter Summary . . . 461
19.10 Background Information . . . 461
19.11 Exercises . . . 462
References . . . 463

20 Conversational CBR . . . 465
20.1 About This Chapter . . . 465
20.2 General Aspects . . . 465
20.3 Conversational CBR . . . 466
20.4 Knowledge Containers . . . 467
20.4.1 The Vocabulary Container . . . 467
20.4.2 The Case Base Container . . . 469
20.4.3 The Similarity Container . . . 469
20.4.4 The Adaptation Container . . . 469
20.5 Basic Conversation Systems . . . 470
20.5.1 Processing the Initial Description . . . 470
20.5.2 Dialogue Management . . . 470
20.5.3 Dialogue Formalisms . . . 472
20.5.4 Lengths of Conversations . . . 475
20.6 Architectures for Dialogues . . . 476
20.7 Quality and Evaluations of Dialogues . . . 478
20.8 More on Dialogues . . . 479

20.8.1 The Role of Thesauri and Ontologies . . . 479
20.8.2 Images in Dialogues . . . 480
20.8.3 Dialogue Case Bases . . . 481
20.9 Domains, Applications, Commercial Use . . . 481
20.10 Tools . . . 482
20.11 Chapter Summary . . . 482
20.12 Background Information . . . 483
20.13 Exercises . . . 484
References . . . 484

21 Knowledge Management . . . 487
21.1 About This Chapter . . . 487
21.2 General Aspects . . . 487
21.3 Knowledge Management . . . 488
21.3.1 Knowledge and Knowledge Management . . . 488
21.3.2 Knowledge and Decision Making . . . 488
21.3.3 Some Knowledge Management Problems . . . 489
21.3.4 Knowledge Management: An Organisational Discipline 489
21.3.5 Knowledge Management Cycle . . . 491
21.4 Case-Based Reasoning and Knowledge Management . . . 491
21.5 CBR Implementing KM Cycles . . . 493
21.5.1 Knowledge Infrastructure and Organisation . . . 493
21.5.2 Knowledge Organisation and Retrieval . . . 494
21.5.3 Knowledge Retrieval and Reuse . . . 495
21.5.4 Knowledge Sharing . . . 497
21.6 For Which KM Tasks Should I Use CBR? . . . 499
21.7 Tools . . . 500
21.8 Chapter Summary . . . 501
21.9 Background Information . . . 501
21.10 Exercises . . . 503
References . . . 503

Part V Additions

22 Basic Formal Definitions and Methods . . . 509
22.1 About This Chapter . . . 509
22.2 General Aspects . . . 509
22.3 Correctness and Logic . . . 510
22.3.1 Propositional Logic . . . 510
22.3.2 Predicate Logic . . . 511
22.3.3 Constraints . . . 514
22.3.4 Rules . . . 514
22.3.5 Reasoning in Logic . . . 515
22.4 Information Theory and Entropy . . . 516
22.5 Utilities . . . 518
22.5.1 Optimization . . . 519

22.6 Chapter Summary 520
22.7 Background Information 520
References 521

23 Relations and Comparisons with Other Techniques 523
23.1 About This Chapter 523
23.2 General Aspects 523
23.3 Systems with Retrieval Engines 524
23.3.1 Database Management Systems 524
23.3.2 Information Retrieval Systems 525
23.3.3 Pattern Recognition Systems 527
23.3.4 Knowledge Comparison for Retrieval Systems 529
23.4 Explicit and Implicit Knowledge Representation 530
23.4.1 Knowledge-Based Systems 530
23.4.2 Machine Learning 531
23.5 Influence Factors 532
23.5.1 Cognitive Science 533
23.5.2 Analogical Reasoning 534
23.5.3 Uncertainty 535
23.6 Chapter Summary 537
23.7 Background Information 537
References 537

Index 539

http://www.springer.com/978-3-642-40166-4

Case-Based Reasoning
A Textbook
Richter, M.M.; Weber, R.
2013, XVIII, 546 p. 180 illus., 7 illus. in color., Hardcover
ISBN: 978-3-642-40166-4