

Table of Contents

Preface	xvii
1. What Is Knowledge Representation?	1
1.1. Introduction	2
1.2. Logic representations	4
1.2.1. Default logic	7
1.2.2. Fuzzy logic	8
1.3. Semantic networks	8
1.3.1. Partitioned networks	12
1.3.2. Marker propagation schemes	14
1.3.3. Topic hierarchies	16
1.3.4. Propositional networks	19
1.3.5. Semantic networks and logic	20
1.4. Procedural representations	21
1.4.1. Winograd's work	21
1.4.2. Procedural semantic networks	24
1.5. Logic programming	26
1.6. Frame-based representations	28
1.7. Production system architectures	33
1.8. Knowledge representation languages	36
1.8.1. KL-One	36
1.8.2. KRYPTON	40
1.8.3. Other languages	41
1.9. Concluding remarks	41
2. Knowledge Representation: What's Important About It?	44
2.1. Introduction	45
2.2. Knowledge for reasoning agents	46
2.3. Modeling the external world	48
2.4. Perception and reasoning by machine	49
2.5. The Nature of the world and its models	52
2.6. The functions of a knowledge representation system	53
2.7. The knowledge acquisition problem	54
2.8. The perception problem	55

2.9. Planning to act	56
2.10. Role of a conceptual taxonomy for an intelligent agent	57
2.11. The structure of concepts	58
2.12. An example of a conceptual taxonomy	60
2.13. The need for taxonomic organization	61
2.14. Recognizing/analyzing/parsing situations	64
2.15. Two aspects of knowledge representation	65
2.16. Expressive adequacy	66
2.17. Notational efficacy	69
2.18. The relationship to formal logic	72
2.19. Concepts are more than predicates	74
2.20. Conclusions	77
3. Some Remarks on the Place of Logic in Knowledge Representation	80
3.1. Introduction	81
3.2. What is logic?	82
3.3. On being logical	85
3.4. Reasoning and logic	87
3.5. Nonmonotonic logic	88
3.6. Conclusion	91
4. Logic and Natural Language	92
4.1. Introduction	93
4.2. Default logic for computing presuppositions	93
4.3. Modal logic for planning utterances	97
4.4. Temporal logic for reasoning about futures	98
4.5. Conclusion	102
5. Commonsense and Fuzzy Logic	103
5.1. Introduction	104
5.2. Meaning representation in test-score semantics	106
5.3. Testing and translation rules	112
5.3.1. Composition of elastic constraints	115
5.4. Representation of dispositions	119
5.5. Reasoning with dispositions	129
5.6. Concluding remark	134

6. Basic Properties of Knowledge Base Systems	137
6.1. Introduction	138
6.2. Basic notions	139
6.3. Completeness & consistency of rule-represented knowledge bases	144
6.4. The case of linear sets of rules	150
6.5. Dependency of rules on attributes	154
6.6. Partial information and defaults	156
6.7. Conclusion	160
7. First Order Logic and Knowledge Representation: Some Problems of Incomplete Systems	161
7.1. Introduction	162
7.2. Prolog & Absys: declarative knowledge manipulation systems	164
7.3. Primitive goal selection strategies in Absys and Prolog	168
7.4. Selection strategies and knowledge systems	171
7.5. Summary	172
8. Admissible State Semantics for Representational Systems	174
8.1. Introduction - the problem of practical semantics	175
8.2. Internal and external meanings	176
8.3. Admissible state semantics	178
8.4. Example: semantic networks	180
8.5. Example: k-lines	184
8.6. Conclusion	185
9. Accelerating Deductive Inference: Special Methods for Taxonomies, Colours and Times	187
9.1. Introduction	188
9.2. Recognizing type relationships	190
9.3. Recognizing part-of relationships	198
9.4. Recognizing colour relationships	203
9.5. Recognizing time relationships	209
9.6. Combining general and special methods	215
9.7. Concluding remarks	219

10. Knowledge Organization and Its Role in Temporal and Causal Signal Understanding: The ALVEN and CAA Projects	221
10.1. Introduction	222
10.2. The representational scheme	222
10.2.1. Knowledge packages: classes	222
10.2.2. Knowledge organization	223
10.2.3. Multi-dimensional levels of detail	224
10.2.4. Time	225
10.2.5. Exceptions and similarity relations	228
10.2.6. Partial results and levels of description	231
10.3. The interpretation control structure	231
10.4. The ALVEN project	232
10.4.1. Overview	232
10.4.2. LV dynamics knowledge and its representation	236
10.5. The CAA project	242
10.5.1. Overview	242
10.5.2. Representation of causal connections	244
10.5.3. Use of causal links	245
10.5.4. Recent research related to causality	246
10.5.5. Representation of domain knowledge	247
10.5.6. Knowledge-base stratification and projection links	252
10.5.7. Recognition strategies and control	252
10.6. Conclusions	261
11. SNePS Considered as a Fully Intensional Propositional Semantic Network	262
11.1. Introduction	263
11.1.1. The SNePS environment	263
11.1.2. SNePS as a knowledge representation system	265
11.1.3. Informal description of SNePS	266
11.2. Intensional knowledge representation	267
11.3. Description of SNePS/CASSIE	272
11.3.1. CASSIE - A model of a mind	272

11.3.2. A conversation with CASSIE	273
11.3.3. Syntax and semantics of SNePS/CASSIE	275
11.3.4. The conversation with CASSIE, revisited	288
11.4. Extensions and applications of SNePS	295
11.4.1. SNePS as a database management system	295
11.4.2. Address recognition for mail sorting	298
11.4.3. NEUREX	300
11.4.4. Representing visual knowledge	301
11.4.5. SNeBR: A belief revision package	304
11.5. Knowledge-based natural language understanding	306
11.5.1. Temporal structure of narrative	308
11.6. Conclusion: SNePS and SNePS/CASSIE as Semantic Networks	311
11.6.1. Criteria for semantic networks	311
11.6.2. SNePS and SNePS/CASSIE vs. KL-One	313
12. Representing Virtual Knowledge Through Logic Programming	316
12.1. Introduction	317
12.2. Representing knowledge in Prolog	318
12.3. Asking for inferences - virtual knowledge	320
12.4. Representing problem-solving knowledge	323
12.5. Representing database knowledge	327
12.6. Limitations	329
12.7. Conclusions	329
13. Theorist: A Logical Reasoning System for Defaults and Diagnosis	331
13.1. Introduction	332
13.2. Prolog as a representation system	333
13.3. The Theorist framework	333
13.4. Tasks appropriate for the Theorist framework	335
13.4.1. Nonmonotonic reasoning - reasoning with default and generalised knowledge	335
13.4.2. Diagnosis	336
13.4.3. Learning as theory construction	341
13.4.4. User modelling as theory maintenance	342
13.4.5. Choices in mundane tasks	343

13.5. Representation and reasoning in theorist	344
13.5.1. Extending Horn clauses to full first order logic	345
13.5.2. Reasoning as the construction of consistent theories	345
13.6. Implementing a Theorist prototype in Prolog	347
13.6.1. Not parallelism	349
13.7. Status and conclusions	351
14. Representing and Solving Temporal Planning Problems	353
14.1. Introduction	355
14.2. The Time Map Manager	358
14.2.1. A Predicate Calculus Database	359
14.2.2. Adding Basic Concepts of Time	364
14.2.3. Events and Persistences	368
14.2.4. Temporal Database Queries	373
14.2.5. Chaining Rules in a Temporal Database	378
14.2.6. A Simple Planner Based on the TMM	382
14.3. The Heuristic Task Scheduler	390
14.3.1. Describing a Resource	392
14.3.2. Describing a Plan	396
14.3.3. Specifying Plan Resource Use	397
14.3.4. Specifying Plan Tasks	399
14.3.5. Specifying Plan Constraints	403
14.3.6. Producing a Completed Linear Task Ordering	406
14.4. Summary and Conclusions	409
15. Analogical Modes of Reasoning and Process Modelling	414
15.1. Introduction to analogical reasoning	415
15.2. WHISPER: A program using analogs	417
15.3. Observations on the use of analogs	421
15.4. Mental rotation as an analog process	423
15.5. Conclusions	428

16. Representing and Using Knowledge of the Visual World	429
16.1. Introduction	430
16.2. Progress in high-level vision	432
16.3. The complexity barrier	435
16.4. Achieving descriptive adequacy	438
16.5. Achieving procedural adequacy	446
16.6. Conclusion	448
17. On Representational Aspects of VLSI-CADT Systems	451
17.1. Introduction	452
17.2. VLSI design process	453
17.2.1. Use of multiple perspectives	454
17.2.2. Almost hierarchical design	456
17.2.3. Constraints and partial specifications	456
17.3. VLSI design knowledge	458
17.3.1. Knowledge about VLSI design	458
17.4. VLSI design representation	459
17.4.1. Representation of designed artifact	460
17.4.2. Design plan	461
17.5. Analysis, testing, and diagnosis of VLSI circuits	462
17.5.1. Reasoning with constraints	462
17.5.2. Qualitative analysis	463
17.5.3. Design for testability frames	464
17.5.4. Logic programming in VLSI design	465
17.5.5. Diagnostic reasoning	466
17.6. Natural language interfaces	466
17.7. Concluding remarks	469
Index	508