

Contents

Temporal Reasoning and Planning.....1

James F. Allen

| | | |
|-------|---|----|
| 1.1 | Introduction..... | 2 |
| 1.1.1 | Background: Actions as State Change..... | 3 |
| 1.1.2 | Temporally Explicit Representations..... | 8 |
| 1.2 | Representing Time | 10 |
| 1.2.1 | Temporal Logic | 16 |
| 1.3 | The Logic of Action | 22 |
| 1.4 | The Logic for Planning | 28 |
| 1.4.1 | Predicting the Future..... | 29 |
| 1.4.2 | Planning With a Temporal World Model..... | 33 |
| 1.5 | The Planning System..... | 36 |
| 1.5.1 | A Nonlinear Planning Algorithm | 40 |
| 1.5.2 | Assumptions About Temporal Extension..... | 47 |
| 1.5.3 | Discussion of the Algorithm | 52 |
| 1.6 | The Door-Latch Problem | 53 |
| 1.7 | Hierarchical Planning..... | 59 |
| 1.8 | Conclusions..... | 67 |

A Formal Theory of Plan Recognition and its Implementation69

Henry A. Kautz

| | | |
|-------|---|----|
| 2.1 | Introduction..... | 70 |
| 2.1.1 | Background | 70 |
| 2.1.2 | Overview..... | 72 |
| 2.1.3 | Plan Recognition and the Frame Problem | 76 |
| 2.2 | Representing Event Hierarchies..... | 77 |
| 2.2.1 | The Language..... | 77 |
| 2.2.2 | Representation of Time, Properties, and Events..... | 77 |
| 2.2.3 | The Event Hierarchy | 78 |
| 2.2.4 | Example: The Cooking World | 80 |

| | | |
|-------|---|-----|
| 2.3 | The Formal Theory of Recognition..... | 83 |
| 2.3.1 | Exhaustiveness Assumptions (EXA)..... | 83 |
| 2.3.2 | Disjointness Assumptions (DJA) | 84 |
| 2.3.3 | Component/Use Assumptions (CUA) | 84 |
| 2.3.4 | Minimum Cardinality Assumptions (MCA)..... | 86 |
| 2.3.5 | Example: The Cooking World | 87 |
| 2.3.6 | Circumscription and Plan Recognition | 89 |
| 2.4 | Examples..... | 97 |
| 2.4.1 | An Operating System..... | 97 |
| 2.4.2 | Medical Diagnosis..... | 101 |
| 2.5 | Algorithms for Plan Recognition | 108 |
| 2.5.1 | Directing Inference..... | 108 |
| 2.5.2 | Explanation Graphs | 109 |
| 2.5.3 | Implementing Component/Use Assumptions..... | 111 |
| 2.5.4 | Constraint Checking..... | 113 |
| 2.5.5 | Algorithms | 115 |
| 2.6 | Conclusions and Caveats | 124 |

Planning With Simultaneous Actions and External Events.....127

Richard N. Pelavin

| | | |
|-------|--|-----|
| 3.1 | Introduction..... | 128 |
| 3.1.1 | Key Considerations..... | 128 |
| 3.1.2 | Overview..... | 130 |
| 3.2 | Representations That Treat Simultaneous Events..... | 131 |
| 3.2.1 | Interval Logic..... | 131 |
| 3.2.2 | A Model Based on Events | 136 |
| 3.2.3 | Branching Time Models..... | 137 |
| 3.2.4 | Adapting the State-Change Model to Handle Simultaneous Events | 139 |
| 3.3 | The Semantic Model..... | 140 |
| 3.3.1 | The Interval Logic Structure..... | 142 |
| 3.3.2 | The Branching Time Structure | 143 |
| 3.3.3 | Plan Instances and Basic Actions..... | 144 |
| 3.3.4 | The Closeness Function | 149 |
| 3.3.5 | Composition and Interaction of Basic Action Instances..... | 154 |

| | | |
|-------|---|------------|
| 3.4 | The Language | 162 |
| 3.4.1 | The Syntax: Additions to Interval Logic | 163 |
| 3.4.2 | Interpretations..... | 165 |
| 3.5 | Planning..... | 168 |
| 3.5.1 | Planner Correctness | 168 |
| 3.5.2 | The World Description | 169 |
| 3.5.3 | The Action Specifications..... | 171 |
| 3.5.4 | Plan Instance Composition | 177 |
| 3.5.5 | Persistence and Maintenance Plan Instances | 179 |
| 3.6 | A Planning Algorithm..... | 182 |
| 3.6.1 | The Input to the Planning Algorithm..... | 183 |
| 3.6.2 | The Algorithm..... | 186 |
| 3.6.3 | Planning Examples..... | 187 |
| 3.6.4 | Limitations of the Planning Algorithm | 194 |
| 3.7 | Discussion | 196 |
| 3.7.1 | Issues Outside the Scope of the Deductive Logic | 197 |
| 3.7.2 | Incomplete Descriptions and Obtaining Additional Information | 199 |
| 3.7.3 | Planning With an Incorrect World Descriptions..... | 200 |
| 3.7.4 | Addressing the Frame Problem..... | 201 |
| 3.8 | Appendix A. The Semantic Model and Logical Language | 202 |
| 3.8.1 | The Semantic Model..... | 202 |
| 3.8.2 | The Syntax | 205 |
| 3.8.3 | The Interpretation of the Language..... | 207 |
| 3.9 | Appendix B. Proof Theory..... | 209 |
| | Abstraction in Planning..... | 213 |
| | Josh D. Tenenberg | |
| 4.1 | Introduction..... | 214 |
| 4.1.1 | Inheritance Abstraction..... | 217 |
| 4.1.2 | Relaxed Model Abstraction..... | 220 |
| 4.1.3 | Macro Expansion | 224 |
| 4.1.4 | Outline..... | 226 |
| 4.1.5 | STRIPS | 226 |
| 4.2 | Inheritance Abstraction..... | 231 |
| 4.2.1 | Generalizing Inheritance..... | 231 |

| | | |
|-------------------------|---|-----|
| 4.2.2 | Predicate Mappings..... | 232 |
| 4.2.3 | Model Abstraction..... | 232 |
| 4.2.4 | Theory Abstraction..... | 233 |
| 4.2.5 | Theory Mappings..... | 235 |
| 4.2.6 | Proof-Theoretic Relationship Between Levels | 237 |
| 4.2.7 | Abstract STRIPS Systems..... | 240 |
| 4.2.8 | Downward Solution Property..... | 242 |
| 4.2.9 | Example..... | 244 |
| 4.2.10 | The Frame Problem..... | 246 |
| 4.2.11 | Comparison With Kautz..... | 246 |
| 4.2.12 | Related Research in Plan Generation | 248 |
| 4.2.13 | Summary..... | 249 |
| 4.3 | Abstraction Using Relaxed Models..... | 249 |
| 4.3.1 | ABSTRIPS..... | 249 |
| 4.3.2 | Planning With Inconsistent Systems..... | 251 |
| 4.3.3 | Restricted ABSTRIPS..... | 252 |
| 4.3.4 | Simple Restrictions | 253 |
| 4.3.5 | Relaxing the Simple Restrictions..... | 255 |
| 4.3.6 | Example..... | 258 |
| 4.3.7 | Upward Solution Property..... | 261 |
| 4.3.8 | The Monotonicity Property | 263 |
| 4.3.9 | Search..... | 269 |
| 4.3.10 | Related Research | 271 |
| 4.3.11 | Summary..... | 271 |
| 4.4 | Conclusion..... | 272 |
| 4.4.1 | Discrete Levels | 272 |
| 4.4.2 | Solution Properties..... | 273 |
| 4.5 | Proofs | 274 |
| 4.5.1 | Proofs for Inheritance Abstraction..... | 274 |
| 4.5.2 | Proofs for Relaxed Model Abstraction | 280 |
| References | 285 | |
| Index | 295 | |