Contents

Introduction 1

1 Conceptual analysis of abduction 5
- What is abduction? 5
- Diagnosis and abductive justification 9
- Doubt and certainty 12
- Explanations give causes 16
- Induction 18
- Taxonomy of basic inference types 27
- From wonder to understanding 28

2 Knowledge-based systems and the science of AI 31
- The science of AI 31
- Knowledge-based systems and knowledge representations 38
- Generic tasks 50

3 Two RED systems – abduction machines 1 and 2 63
- The red-cell antibody identification task 63
- The common architecture underlying RED-1 and RED-2 66
- The RED-1 Overview mechanism 75
- The RED-2 Overview mechanism 78
- Hypothesis interactions 91

4 Generalizing the control strategy – machine 3 94
- The PEIRCE tool 94
- Reimplementing RED in PEIRCE 101
- Abduction in SOAR 105
- Generic tasks revisited 113

5 More kinds of knowledge: Two diagnostic systems 117
- TIPS 117
- PATHEX/LIVER: Structure–function models for causal reasoning 123

6 Better task analysis, better strategy – machine 4 136
- Abduction machines – summary of progress 136

Task analysis of explanatory hypothesis formation 139
Concurrent assembly 142
Concurrent realization of the essentials-first strategy: Framework 147
Efficiency of the essentials-first strategy 151

7 The computational complexity of abduction 157
Introduction 157
Background 158
Notation, definitions, and assumptions 159
Complexity of finding explanations 164
Complexity of plausibility 171
Application to red-cell antibody identification 176
Discussion 177

8 Two more diagnostic systems 180
Distributed abduction in MDX2 181
QUAWDS: Diagnostic system for gait analysis 184
An abductive approach to knowledge-base refinement 196

9 Better task definition, better strategy – machine 5 202
Tractable abduction 202
Software: PEIRCE-IGTT 215
Experiment: Uncertainty and correctness 223

10 Perception and language understanding 238
Perception is abduction in layers 238
Computational model of abduction in layers 242
Speech understanding as layered abduction 246
Three pilot speech recognition systems 250
Multisense perception 258
Knowledge from perception 259

Appendix A Truth seekers 262
Abduction machines 262
In synthetic worlds 264

Appendix B Plausibility 266
Plausibility and probability 267
The need to go beyond probability 270
Dimensions of plausibility 271
Alternatives to probability 271
Plausibility and intelligence 272

Extended Bibliography 273

Acknowledgments 291

Index 295