Contents

	Acknowledgments			
1	Introduction			
	1.1	Meaning, Understanding, and Thought	2	
	1.2	A Road Map	5	
2	The Mind Is a Computer Program			
	2.1	Evolution as Computation	47	
	2.2	The Program of Life	52	
3	The Turing Test, the Chinese Room, and What Computers Can't Do			
	3.1	The Turing Test	69	
	3.2	Semantics vs. Syntax	75	
4	Occam's Razor and Understanding			
	4.1	Neural Nets and Other Curves	80	
	4.2	Minimum Description Length	93	
	4.3	Bayesian Statistics	95	
	4.4	Summary	102	
5	Optimization			
	5.1	Hill Climbing	109	
	5.2	The Fitness Landscape	109	
	5.3	What Good Solutions Look Like	111	
	5.4	Back-Propagation	116	
	5.5	Why Hill Climbing Works	118	
	5.6	Biological Evolution and Genetic Algorithms	120	
	5.7	Summary	125	
	Appendix: Other Potential Problems with the Search for a Turing Machine Input			
	Machine Input			
6	Rem	arks on Occam's Razor	129	
	6.1	Why the Inner Workings of Understanding Are Opaque	129	
	6.2	Are Compact Representations Really Necessary?	135 142	
	Appendix: The VC Lower Bound			
7	Reinforcement Learning			
	7.1	Reinforcement Learning by Memorizing the State-Space	146	
	7.2	Generalization by Building a Compact Evaluation Function	149	
	7.3	Why Value Iteration Is Fundamentally Suspect	153	

	7.4	Why Neural Nets Are Too Weak a Representation	155
	7.5	Reaction vs. Reflection	157
	7.6	Evolutionary Programming, or Policy Iteration	159
8	Exp	loiting Structure	165
	8.1	What Are Objects?	168
	8.2	A Concrete Example: Blocks World	174
	8.3	Games	187
	8.4	Why Hand-Coded AI Programs Are Clueless	206
	8.5	Another Way AI Has Discarded Structure	208
	8.6	Platonism vs. Reality	211
	App	endix: Plan Compilation	212
9	Moo	iules and Metaphors	215
	9.1	Evidence for a Modular Mind	215
	9.2	The Metaphoric Nature of Thought	220
	9.3	The Metaphoric Nature of Thought Reflects Compressed Code	225
	9.4	New Thought and Metaphor on the Fly	228
	9.5	Why a Modular Structure?	230
10	Evo	lutionary Programming	233
10	Evo 10.1	• • •	233 240
10		An Economic Model	
10	10.1	An Economic Model The Hayek Machine	240
10	10.1 10.2 10.3	An Economic Model The Hayek Machine	240 250 266 271
	10.1 10.2 10.3	An Economic Model The Hayek Machine Discussion actability	240 250 266 271 271
	10.1 10.2 10.3 Intr : 11.1	An Economic Model The Hayek Machine Discussion actability	240 250 266 271
	10.1 10.2 10.3 Intr : 11.1	An Economic Model The Hayek Machine Discussion actability Hardness Polynomial Time Mapping	240 250 266 271 271 281 286
	10.1 10.2 10.3 Intr 11.1 11.2	An Economic Model The Hayek Machine Discussion actability Hardness Polynomial Time Mapping So, How Do People Do It?	240 250 266 271 271 281
	10.1 10.2 10.3 Intr 11.1 11.2 11.3 11.4	An Economic Model The Hayek Machine Discussion actability Hardness Polynomial Time Mapping So, How Do People Do It?	240 250 266 271 271 281 286
11	10.1 10.2 10.3 Intr 11.1 11.2 11.3 11.4	An Economic Model The Hayek Machine Discussion actability Hardness Polynomial Time Mapping So, How Do People Do It? Constraint Propagation Evolution of Learning	240 250 266 271 271 281 286 293
11	10.1 10.2 10.3 Intr 11.1 11.2 11.3 11.4 The	An Economic Model The Hayek Machine Discussion actability Hardness Polynomial Time Mapping So, How Do People Do It? Constraint Propagation Evolution of Learning Learning and Development	240 250 266 271 271 281 286 293 303
11	10.1 10.2 10.3 Intra 11.1 11.2 11.3 11.4 The 12.1	An Economic Model The Hayek Machine Discussion actability Hardness Polynomial Time Mapping So, How Do People Do It? Constraint Propagation Evolution of Learning Learning and Development Inductive Bias	240 250 266 271 271 281 286 293 303 308
11	10.1 10.2 10.3 Intr 11.1 11.2 11.3 11.4 The 12.1 12.2	An Economic Model The Hayek Machine Discussion actability Hardness Polynomial Time Mapping So, How Do People Do It? Constraint Propagation Evolution of Learning Learning and Development Inductive Bias Evolution and Inductive Bias	240 250 266 271 281 286 293 303 308 316
11	10.1 10.2 10.3 Intr 11.1 11.2 11.3 11.4 The 12.1 12.2 12.3 12.4 12.5	An Economic Model The Hayek Machine Discussion actability Hardness Polynomial Time Mapping So, How Do People Do It? Constraint Propagation Evolution of Learning Learning and Development Inductive Bias Evolution and Inductive Bias Evolution's Own Inductive Bias The Inductive Bias Evolution Discovers	240 250 266 271 271 281 286 293 303 308 316 319
11	10.1 10.2 10.3 Intra 11.1 11.2 11.3 11.4 The 12.1 12.2 12.3 12.4	An Economic Model The Hayek Machine Discussion actability Hardness Polynomial Time Mapping So, How Do People Do It? Constraint Propagation Evolution of Learning Learning and Development Inductive Bias Evolution and Inductive Bias Evolution's Own Inductive Bias The Inductive Bias Evolution Discovers	240 250 266 271 271 281 286 293 303 308 316 319 320

	12.8	The Interaction of Learning during Life and Evolution	331
	12.9	Culture: An Even More Powerful Interaction	335
	12.10	A Case Study: Language Learning as an Example of	
		Programmed Inductive Bias	337
	12.11	Grammar Learning and the Baldwin Effect	343
	12.12	Summary	346
13	Language and the Evolution of Thought		
	13.1	The Evolution of Behavior from Simple to Complex Creatures	351
	13.2	Review of the Model	360
	13.3	What Is Language?	365
	13.4	Gavagai	367
	13.5	Grammar and Thought	370
	13.6	Nature vs. Nurture: Language and the Divergence between	
		Apes and Modern Humankind	374
	13.7	The Evolution of Language	378
	13.8	Summary	382
14	The Evolution of Consciousness		
	14.1	Wanting	387
	14.2	The Self	403
	14.3	Awareness	408
	14.4	Qualia	424
	14.5	Free Will	426
	14.6	Epilogue	436
15	What	Is Thought?	437
	Notes	5	443
	References		455
	Index		465