## **C**ONTENTS

Preface			v
1	Introd	luction	1
	1.1	The origins of natural language processing	2
	1.2	The imposition of structure	5
	1.3	The representation of meaning	8
	1.4	The role of knowledge	12
	1.5	The emergence of a new technology	15
	1.6	Using Prolog for natural language processing	17
2	Finite-	state techniques	21
	2.1	Finite-state transition networks	22
	2.2	A notation for networks	27
	2.3	Representing FSTNs in Prolog	37
	2.4	Traversing FSTNs	40
	2.5	Traversing FSTNs in Prolog	43
	2.6	Finite-state transducers	50
	2.7	Implementing FSTs in Prolog	57
	2.8	Limitations of finite-state machines	59
3	Recurs	sive and augmented transition networks	63
	3.1	Recursive transition networks	64
	3.2	Modelling recursion in English grammar	68
	3.3	Representing RTNs in Prolog	72
	3.4	Traversing RTNs	73
	3.5	Implementing RTN traversal in Prolog	79
	3.6	Pushdown transducers	82
	3.7	Implementing pushdown transducers in Prolog	87
	3.8	Advantages and limitations of RTNs	89
	3.9	Augmented transition networks	91
	3.10	Some reflections on ATNs	95
			xiii

	1		
4	Grammars		
	l 4.1	Grammar as knowledge representation	100
	4.2	Words, rules and structures	104
	4.3	Representing simple grammars in Prolog	110
	4.4	Subcategorization and the use of features	115
	4.5	Definite clause grammars	127
	4.6	Classes of grammars and languages	132
5	Parsin	g, search and ambiguity	143
	5.1	A simple parsing problem	144
	5.2	Bottom-up parsing	145
	5.3	Top-down parsing	152
	5.4	Parsing in Prolog	156
	5.5	Comparing strategies	165
	5.6	Breadth-first and depth-first search	166
	5.7	Storing intermediate results	168
	5.8	Ambiguity	169
	5.9	Determinism and lookahead	174
6	Well-f	ormed substring tables and charts	179
	6.1	Well-formed substring tables	180
	6.2	The active chart	189
	6.3	The fundamental rule of chart parsing	193
	6.4	Initialization	196
	6.5	Rule invocation	196
	6.6	Housekeeping	199
	6.7	Implementing a simple bottom-up chart parser	200
	6.8	Alternative rule invocation strategies	202
	6.9	Implementing a simple top-down chart parser	204
		Search strategy	205
	6.11	1	207
	6.12	Efficiency	213
7	Featur	res and the lexicon	217
	7.1	Feature-theoretic syntax	218
	7.2	Feature structures as graphs	221
	7.3	Feature structures in Prolog	228
	7.4	Subsumption and unification	230
	7.5	The status of rules	238
	7.6	Implementing PATR in Prolog	240
	7.7	Chart parsing with feature-based grammars	248
	7.8	Representation of lexical knowledge	256
	7.9	Implementing a lexicon in Prolog	270
	7.10	DAGs versus terms	273

8	Semai	ntics	279
	8.1	Compositionality	280
	8.2	Meaning as reference	282
	8.3	Translation to a meaning representation language	288
	8.4	A database query language	290
	8.5	Computational semantics as feature instantiation	293
	8.6	Transitive verbs and quantification	294
	8.7	Ambiguity, preferences and timing	301
	8.8	Building semantic checking into the grammar	303
9	Quest	ion answering and inference	313
	9.1	Ouestion answering	314
	9.2	Evaluating DBQ formulae	318
	9.3	Standard logical inference	325
	9.4	Implementing forwards inference in Prolog	333
	9.5	The pathological nature of logical inference	339
	9.6	Primitives and canonical forms	343
	9.7	Classes and inheritance	347
	9.8	Plausible inference and defaults	353
10	Pragr	natics	359
	10.1	Ambiguity and levels of language processing	360
	10.1	Semantic and pragmatic roles of noun phrases	361
	10.2	Given versus new information	364
	10.3	Understanding by prediction	372
	10.4	More controlled versions of prediction	376
	10.5	Problems with prediction	381
	10.0	Using discourse structure	382
	10.7	Language generation as a goal-oriented process	386
	10.8	Language understanding and plan recognition	398
Append	ix Cod	e listings	403
Solution	ıs to sele	cted exercises	469
Bibliogr	aphy		473
Name I	ndex		497
C	T. 3		501

**General Index**