NATURAL LANGUAGE PROCESSING IN LISP

An Introduction to Computational Linguistics

Gerald Gazdar

University of Sussex

Chris Mellish

University of Edinburgh



Addison-Wesley Publishing Company

Wokingham, England · Reading, Massachusetts · Menlo Park, California New York · Don Mills, Ontario · Amsterdam · Bonn Sydney · Singapore · Tokyo · Madrid · San Juan

CONTENTS

Preface			v
1	Introdu	uction	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 LISP for natural language processing	17
2	Finite-	state techniques	21
	2.1	Finite-state transition networks	22
	2.2	A notation for networks	27
		Deterministic FSTNs in LISP	37
		Non-deterministic FSTNs in LISP	38
	2.5	Traversing FSTNs	41
	2.6	Traversing FSTNs in LISP	44
	2.7	Finite-state transducers	50
	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	Traversing RTNs	72
	3.4	RTNs in LISP	78
	3.5	Pushdown transducers	82
	3.6	Advantages and limitations of RTNs	88
	3.7	Augmented transition networks	89
	3.8	Developing ATNs	93
	3.9	Implementation of ATNs	99
	3.10	Some reflections on ATNs	107
			xii

4	Grammars	111
	4.1 Grammar as knowledge representation	112
	4.2 Words, rules and structures	116
	4.3 Grammars in LISP and random generation	122
	4.4 Subcategorization and the use of features	127
	4.5 Encoding feature specifications in LISP	138
	4.6 Classes of grammars and languages	142
5	Parsing, search and ambiguity	149
	5.1 A simple parsing problem	150
	5.2 Bottom-up parsing	151
	5.3 Top-down parsing	161
	5.4 Comparing strategies	166
	5.5 Breadth-first and depth-first search	168
	5.6 Storing intermediate results	170
	5.7 Ambiguity	172
	5.8 Determinism and lookahead	176
6	Well-formed substring tables and charts	181
	6.1 Well-formed substring tables	182
	6.2 The active chart	191
	6.3 The fundamental rule of chart parsing	195
	6.4 Initialization	201
	6.5 Rule invocation	203
	6.6 Search strategy	205
	6.7 Housekeeping	207
	6.8 Alternative rule invocation strategies	209
	6.9 Efficiency	211
7	Features and the lexicon	215
	7.1 Feature-theoretic syntax 7.2 Feature structures as graphs	216 219
	7.3 Feature structures in LISP	226
	7.4 Subsumption and unification	228
	7.5 The status of rules	237
	7.6 Representing PATR grammars in LISP	239
	7.7 Random generation revisited	244
	7.8 Chart parsing with feature-based grammars	249
	7.9 Representation of lexical knowledge	260
	7.10 Implementing a lexicon in LISP	27:
	7.11 DAGs versus terms	270

8	Semantics	283
	8.1 Compositionality	284
	8.2 Meaning as reference	286
	8.3 Translation to a meaning represen	
	8.4 A database query language	294
	8.5 Computational semantics as featur	re instantiation 297
	8.6 Transitive verbs and quantification	1 299
	8.7 Ambiguity, preferences and timing	
	8.8 Building semantic checking into the	ne grammar 307
9	Question answering and inference	317
	9.1 Question answering	318
	9.2 Evaluating DBQ formulae	321
	9.3 Standard logical inference	330
	9.4 Implementing backwards and forw	
	9.5 The pathological nature of logical	
	9.6 Primitives and canonical forms	348
	9.7 Inheritance and defaults	351
	9.8 A simple semantic network in LIS	P 357
10	n di	2/2
10	Pragmatics	363
	10.1 Ambiguity and levels of language	
	10.2 Semantic and pragmatic roles of n	•
	10.3 Given versus new information	368
	10.4 Understanding by prediction	376
	10.5 More controlled versions of predictions	
	10.6 Problems with prediction	385
	10.7 Using discourse structure	386
	10.8 Language generation as a goal-ori	
	10.9 Language understanding and plan	recognition 402
Appendi	ix Code listings	407
Solution	s to selected exercises	487
Bibliogr	aphy	495
Name Ir	ndex	517
General	Index	521