CONTENTS

GENERAL INTRODUCTION, 1

Part I
SEMANTICS IN INFORMATION PROCESSING SYSTEMS, 7

Chapter 1 THE HEURISTIC COMPILER, 9
Herbert A. Simon

1 Experiments with a Heuristic Compiler, 10

1.1 Theory of Problem Solving, 10
1.2 Program Writing as Problem Solving, 11
1.3 Outline of a Heuristic Compiler for IPL-V, 12
1.4 Some Characteristics of IPL-V, 13
1.5 State Description Compiler, 13
1.6 Functional Description Compiler, 16
1.7 General Compiler, 18
1.8 Relation of the Heuristic Compiler to the General Problem Solver, 21
1.9 Flow Diagrams, 21
1.10 Summary, 24

2 General Implications for Representations, 25

2.1 Language and Representations in the Compiler, 25
2.2 The Design of Representations, 28

3 Experiments with Representations, 31

3.1 Generalized Processes, 32
3.2 Definite Descriptions, 37
3.3 Compilation of Routines from Partial Descriptions, 40

Chapter 2 SOME SEMANTIC METHODS FOR LANGUAGE PROCESSING, 44
Laurent Siklóssy and H. A. Simon

1 Introduction, 44

1.1 Semantics, 45
1.2 The Point of View, 46
1.3 Hearer, Speaker, and Learner, 47
1.4 Ambiguity and Synonymy, 47
1.5 Syntax and Generality, 48
1.6 The Programs, 49

2 Hearer Programs, 51

2.1 Organization of the Processing, 51
2.2 Structuring the Input, 52
2.3 Using the Structured Input, 54
2.4 Types of Stored Knowledge, 59
2.5 Inference and Response, 60

3 Speaker Programs, 61

4 A Learner Program, 63

5 Conclusion, 64

Part II
GENERATING INTERNAL REPRESENTATIONS, 67

Chapter 3 SOME STUDIES IN GAME PLAYING WITH A DIGITAL COMPUTER, 71
Thomas G. Williams

1 Introduction, 71

1.1 A Brief Survey of Game-Playing Programs, 71
1.2 Definition of the Problem, 72

2 GGPP and Human Behavior, 73

2.1 General Information and Experience, 74
2.2 Form and Interrelations of Objects, 74
2.3 The Rules of the Game, 75

3 Use of the System, 75

3.1 The Programming System, 75
3.2 Basic Forms of GPL Data, 76
3.3 Interpretation of Statements and Programs, 81
3.4 Input Card Format, 83
3.5 Special Facilities of GPL, 84

4 Examples of Games, 99

4.1 Tic-Tac-Toe, 99
4.2 Checkers, 103
4.3 Eights, 107
4.4 Hearts, 111
4.5 Conclusions, 116

5 Internal Representation, 117

5.1 Specifications for an Internal Representation, 117
5.2 Evaluation of the Internal Representation, 118
5.3 Some Conclusions about the Representation, 122
5.4 Some Other Representations, 123

6 Problems in Learning and Generalization, 124

6.1 Move Selection, 124
6.2 Subgoal Generation, 125

7 Generality, 127

7.1 Trick-Winning Card Games, 128
7.2 Stops, 130
7.3 Poker and Rummy, 130
7.4 Other Card Games, 132
7.5 Board Games, 133
7.6 Conclusions, 133

8 Conclusions, 133

Appendix Primitive Routines, 134

Chapter 4 COMPUTER PROGRAM ORGANIZATION INDUCED FROM PROBLEM EXAMPLES, 143
Donald S. Williams

1 The Aptitude Test Taker, 143

1.1 Antecedents, 144
1.2 Procedure, 145
1.3 Structure, 145
1.4 Organization of this Study, 146

2 Data Representation, 147

2.1 Test Item Representation, 147
2.2 Task Form Specification, 148
2.3 Test Item Taker, 151
2.4 Test Item Description, 152

3 Implementation, 155

3.1 Test Form Analyzer, 155
3.2 Forming the Test Item Taker, 159
3.3 Operation of the TIT, 161

4 Comparison, 166

4.1 Test Selection, 167
4.2 Test Battery, 169
4.3 Aptitude Tests, 171
4.4 Test Items, 176

5 Other Approaches, 185

5.1 Transformation Graphs, 186
5.2 Catalog of Operations, 188
5.3 Program Organization, 190

6 Problem Solvers, 191

6.1 The Concept Former, 191
6.2 The General Problem Solver, 194
6.3 Sequence Prediction Program, 196

7 Summary, 197

7.1 Method, 197
7.2 Results, 198

Appendix Description of Aptitude Tests Used with the Aptitude Test Taker, 199

Part III
USE OF CONTEXT IN DETERMINING MEANING, 207

Chapter 5 SYNTAX DIRECTED INTERPRETATION OF NATURAL LANGUAGE, 211
L. Stephen Coles

1 Introduction, 211

1.2 Definition of the Problem, 211
1.2 Reasons for Wanting Natural Language and Picture Input, 213
1.3 Related Systems, 216

2 An Integrated Linguistic Description, 223

2.1 The Syntactic Component, 224
2.2 The Semantic Company, 225
2.3 Relation Between Syntax and Semantics, 227
2.4 The Pragmatic Component, 229
2.5 Productions, 231
2.6 Natural Inference Systems, 232

3 GRANIS, A Computer Model, 241

3.1 Program Structure, 242
3.2 Results, 255

4 Extensions, 261

4.1 Habitability, 261
4.2 Inferential Power, 265
4.3 Knowledge Acquisition, 273
4.4 Adaptive Properties, 275

5 Conclusions, 278

Chapter 6 NATURAL LANGUAGE LEARNING BY COMPUTER, 288
Laurent Siklóssy

1 Introduction, 288

2 The Program and Representation, 290

2.1 The Functional Language, FL, 290
2.2 The Program's Internal Representation, 292
2.3 The Program's Organization, 296

3 Learning Russian, 304

4 A Critical Look at ZBIE, 319

5 Envoi, 322

Appendix Evolutionary Learning, 323

Part IV

REPRESENTATION BY DESCRIPTION AND MODELING, 329

Chapter 7 A GOAL-ORIENTED LANGUAGE FOR THE COMPUTER, 331

Harry E. Pople, Jr.

1 Introduction, 331

- **1.1** Description vs. Model in Problem Solving, 332
- **1.2** A Descriptive Formulation of the Task, 333
- **1.3** A Model Formulation of the Task, 338
- **1.4** Representation and Process, 339
- **1.5** A Synthesis of Description and Model, 341

2 The GOL Programming System, 343

- **2.1** Overview, 343
- **2.2** Syntax of GOL Expressions, 347
- **2.3** Semantics of GOL Expressions, 350
- **2.4** Pragmatics of the Language, 352
- **2.5** Use of Recursive GOL Expressions, 360
- **2.6** Summary, 367

3 Examples of GOL Programming, 368

- **3.1** The Maze Examples Revisited, 368
- **3.2** The GOL Advice Taker, 369
- **3.3** Critique of the Advice Taker, 376
- **3.4** The GOL General Problem Solver, 378
- **3.5** The Revised Monkey Problem, 381
- **3.6** The Logic Theorist in GOL, 387

4 Summary and Conclusions, 393

- **4.1** Proposed Revisions and Extensions of the GOL System, 393
- **4.2** Areas for Further Research, 396

Appendix A Relation to Contemporary Work, 397

A.1 Green's System QA3, 397
A.2 Fikes' System REF, 400

Appendix B The GOL Compiler and Evaluation Routines, 403

B.1 Primitive Generators, 403
B.2 Composite Generators, 404
B.3 Conjunctive Expressions and Cascaded Generators, 405
B.4 The GOL Executive and GOLIST, 407
B.5 Disjunctive Expressions and Parallel Generators, 409
B.6 Implicative Expressions and the Universal Quantifier, 409
B.7 Run-Time Routines, 411
B.8 Termination of Search, 411

Chapter 8 ON REASONING ABOUT ACTIONS, 414
Herbert A. Simon

1 Actions, 415

2 Models, 415

3 Proofs, 416

4 Incomplete Descriptions, 417

5 The Monkey-Banana Problem, 420

6 Comments on Models, 421

7 Symmetries, 422

8 Hereditary Properties, 423

8.1 Cube-brick Problem, 424
8.2 Rule of the Square, 425
8.3 NIM, 425

9 Model Subspaces, 426

10 Non-Independence, 427

10.1 Resource Limitation, 427
10.2 Specific Requirements, 428
10.3 Temporal Interdependence, 429
10.4 Analysis in Chess, 430

Index, 431