

Contents

1	Introduction	1
1.1	Knowledge Representation and Reasoning	1
1.1.1	Knowledge-Based Systems	2
1.1.2	Requirements for a Knowledge Representation Formalism ..	3
1.2	Conceptual Graphs	8
1.2.1	Basic Notions	8
1.2.2	Subsumption and Homomorphism	9
1.2.3	Formal Semantics	11
1.2.4	Full CGs	12
1.3	A Graph-Based Approach to KR	13
1.3.1	Motivations	13
1.3.2	Extensions of the Basic Formalism	14
1.3.3	Several Approaches to CGs	16

Part I Foundations: Basic and Simple Conceptual Graphs

2	Basic Conceptual Graphs	21
2.1	Definition of Basic Conceptual Graphs (BGs)	22
2.1.1	Vocabulary	22
2.1.2	Basic Conceptual Graphs	25
2.1.3	SubBGs and PseudoBGs	29
2.2	BG Homomorphism	30
2.2.1	Subsumption and Homomorphism	30
2.2.2	Bijjective Homomorphisms and Isomorphisms	33
2.2.3	BG Queries and Answers	34
2.3	BG Subsumption Properties	35
2.3.1	Subsumption Preorder	35
2.3.2	Irredundant BGs	37
2.4	Generalization and Specialization Operations	40
2.4.1	Elementary Generalization Operations for BGs	40
2.4.2	Generalization and Homomorphism	42

2.4.3	Elementary Specialization Operations	45
2.4.4	Specialization and Homomorphism	48
2.5	Normal BGs	49
2.5.1	Definition of Normal BGs	49
2.5.2	Elementary Operations for Normal BGs	52
2.6	Complexity of Basic Problems	54
2.7	Bibliographic Notes	56
3	Simple Conceptual Graphs	59
3.1	Introduction	60
3.2	Vocabulary	62
3.3	Simple Conceptual Graphs (SGs)	66
3.4	Generalization and Specialization Operations	69
3.5	Standard and Normal SGs	71
3.6	Coref-Homomorphism	72
3.7	Antinormal Form and Homomorphism	76
3.8	Bibliographic Notes	80
4	Formal Semantics of SGs	83
4.1	Model Semantic	84
4.1.1	Models of SGs	84
4.1.2	Soundness and Completeness of (coref) Homomorphism	87
4.2	Logical Semantic	89
4.2.1	The FOL Semantic Φ	89
4.2.2	Model Semantic and Φ	91
4.3	Positive, Conjunctive, and Existential Fragment of FOL	92
4.3.1	Ordered Language and \mathcal{L} -Substitution	93
4.3.2	Soundness and Completeness Revisited	94
4.3.3	Relationships Between SGs and FOL(\wedge, \exists)	95
4.3.4	Another FOL Semantic: Ψ	98
4.4	Note on the Relationships Between Description Logics and Conceptual Graphs	100
4.5	Bibliographic Notes	104
5	BG Homomorphism and Equivalent Notions	105
5.1	Conceptual Graphs and Conceptual Hypergraphs	107
5.1.1	Conceptual Hypergraphs	107
5.1.2	Different Kinds of Vocabularies	110
5.2	Graphs	113
5.2.1	From Graphs to BGs	114
5.2.2	From BGs to Graphs	117
5.3	Relational Structures and Databases	119
5.3.1	Relational Structures and BGs	119
5.3.2	Conjunctive Queries and BGs	120
5.4	Constraint Satisfaction Problem	124

5.4.1	Definition of CSP	124
5.4.2	From CSP to BGs	127
5.4.3	From BGs to CSP	128
5.5	Bibliographic Notes	132

Part II Computational Aspects of Basic Conceptual Graphs

6	Basic Algorithms for BG Homomorphism	135
6.1	Algorithms for BG Homomorphisms	135
6.1.1	Basic Backtrack Algorithms	136
6.1.2	Backtrack Improvements	141
6.2	Constraint Processing	151
6.2.1	A Panorama of Constraint Processing Techniques	151
6.2.2	Arc-Consistency	154
6.2.3	Forward Checking	159
6.3	Label Comparison	161
6.3.1	Basic Data Structures and Algorithms	163
6.3.2	Related Problems	164
6.3.3	Tree Orders	166
6.3.4	Partition in Chains	167
6.3.5	Lattices	168
6.4	Bibliographic Notes	169
7	Tractable Cases	171
7.1	Introduction	171
7.1.1	About Tractability	172
7.1.2	The Structure of the <i>Target</i> BG is of No Help	172
7.2	Tractability Based on the Multigraph-Acyclicity of the <i>Source</i> BG	174
7.2.1	Acyclic Multigraphs and Trees	174
7.2.2	BGs Trivially Logically Equivalent to Acyclic BGs	184
7.3	Tractability Based on the Hypergraph-Acyclicity of the Source BG	185
7.3.1	Use of a Join Tree	187
7.3.2	Construction of a Join Tree	191
7.3.3	Equivalence with the Existential Conjunctive Guarded Fragment	193
7.4	Generalizations of Graph-Acyclicity and Hypergraph-Acyclicity	198
7.4.1	Graphs and Treewidth	198
7.4.2	Hypergraphs and Hypertreewidth	200
7.4.3	Expressivity Results	201
7.5	What About Labels?	202
7.6	Complementary Notes	204

8	Other Specialization/Generalization Operations	207
8.1	The Least Generalization and Greatest Specialization of Two BGs	208
8.2	Basic Compatibility Notions and Maximal Joins	212
8.2.1	Compatible Node Set	212
8.2.2	Maximal Join	215
8.3	Compatible Partitions and Extended Join	222
8.3.1	Compatible C-Partition and R-Partition	222
8.3.2	Extended Join	226
8.3.3	Join According to a Compatible Pair of C-Partitions	226
8.4	\mathcal{G} -Specializations	228
8.4.1	Surjective Homomorphism	228
8.4.2	Union	229
8.4.3	Inductive Definition of BGs	231
8.4.4	\mathcal{G} -Specializations	232
8.5	Type Expansion and Contraction	235
8.6	Bibliographic Notes	242
 Part III Extensions		
9	Nested Conceptual Graphs	247
9.1	Introduction	248
9.2	Nested Basic Graphs (NBGs)	249
9.3	Nested Graphs (NGs)	256
9.4	Nested Typed Graphs	258
9.5	The Semantics Φ_N	262
9.5.1	Definition of Φ_N	263
9.5.2	Soundness and Completeness	265
9.6	Representation of Nested Typed Graphs by BGs	267
9.7	Bibliographic Notes	270
10	Rules	273
10.1	Definition and Logical Semantics of a Rule	273
10.1.1	Logical Semantics of a Rule	276
10.1.2	Rule as a Bicolored Graph	277
10.2	Forward Chaining	278
10.2.1	Rule Application	279
10.2.2	Derivation and Deduction	281
10.2.3	Non-Redundant Rule Application	284
10.2.4	Soundness and Completeness of Forward Chaining	286
10.3	Backward Chaining	291
10.3.1	Outline of the Backward Chaining Mechanism	292
10.3.2	Piece Resolution	294
10.3.3	Soundness and Completeness of Backward Chaining	298
10.4	Computational Complexity of \mathcal{FR} -DEDUCTION with Rules	301
10.4.1	Semi-Decidability of \mathcal{FR} -DEDUCTION with Rules	301

10.4.2	Decidable Cases	303
10.5	Bibliographic Notes	307
11	The BG Family: Facts, Rules and Constraints	311
11.1	Overview of the BG Family	311
11.2	\mathcal{FC} : Facts and Constraints	313
11.2.1	Positive and Negative Constraints	313
11.2.2	Translation to FOL	316
11.2.3	Complexity of Consistency and Deduction	318
11.3	Combining Rules and Constraints	321
11.3.1	\mathcal{FRC} : Constraints and Inference Rules	321
11.3.2	\mathcal{FEC} : Constraints and Evolution Rules	325
11.3.3	\mathcal{FREEC} : Constraints, Inference and Evolution Rules	326
11.3.4	Complexity of Combining Rules and Constraints	326
11.4	Complexity in $\mathcal{FRC}/\mathcal{FEC}/\mathcal{FREEC}$ for Particular Cases of Rules and Constraints	327
11.4.1	Particular Cases of Rules	327
11.4.2	Particular Cases of Constraints	330
11.5	Bibliographic Notes	334
12	Conceptual Graphs with Negation	337
12.1	Full Conceptual Graphs	338
12.1.1	Existential Graphs: a Diagrammatical System for Logics	338
12.1.2	Full Conceptual Graphs (FCGs)	340
12.1.3	Logical Semantics of FCGs	342
12.1.4	Equivalence of CGs and FOL	344
12.1.5	FCG Calculus	346
12.1.6	Dau's FCGs	347
12.1.7	Kerdiles' FCGs	348
12.2	Conceptual Graphs with Atomic Negation	350
12.2.1	Polarized Graphs	350
12.2.2	Handling Coreference and Difference	355
12.2.3	PG-DEDUCTION and Equivalent Problems	359
12.2.4	Complexity of PG-DEDUCTION	360
12.2.5	Special Cases with Lower Complexity for PG-DEDUCTION	362
12.2.6	Algorithmic Improvements	367
12.2.7	Querying Polarized Graphs	371
12.2.8	Note on Negation and Rules	374
12.3	Bibliographic Notes	375
13	An Application of Nested Typed Graphs: Semantic Annotation Bases	377
13.1	Annotation	377
13.1.1	Annotations, Metadata and Resources	377
13.1.2	Examples of Annotation Base Uses	378
13.1.3	Components of an Annotation System	380

13.2	Annotation Base	381
13.2.1	Exact Knowledge	382
13.2.2	Modules	383
13.2.3	Plausible Knowledge	384
13.3	Querying an Annotation Base	385
13.3.1	Exact Search	386
13.3.2	Approximate Search	386
13.4	Annotation and the Semantic Web	388
13.5	Conclusion	390
A	Mathematical Background	393
A.1	Sets and Relations	394
A.1.1	Sets and Elements	394
A.1.2	Relations and Mappings	395
A.2	Graphs	397
A.2.1	Directed Graphs	397
A.2.2	Homomorphism	399
A.2.3	Different Sorts of Graphs	400
A.2.4	Hypergraphs	403
A.3	Ordered Sets	403
A.3.1	Basic Notions	403
A.3.2	Lattices	405
A.4	First Order Logic (FOL)	406
A.4.1	Syntax	406
A.4.2	Semantics and Models	408
A.4.3	Clausal Form	409
A.4.4	Resolution and SLD-Resolution	409
A.5	Algorithm and Problem Complexity	410
	References	413
	Index	423



<http://www.springer.com/978-1-84800-285-2>

Graph-based Knowledge Representation
Computational Foundations of Conceptual Graphs

Chein, M.; Mugnier, M.-L.

2009, XIV, 428 p., Hardcover

ISBN: 978-1-84800-285-2