

Contents of Volume 3

Chapter 1. Tree Languages	
<i>Ferenc Gécseg and Magnus Steinby</i>	1
1. Introduction.....	1
2. Trees and terms	2
3. Algebraic preliminaries	5
4. Term rewriting systems	8
5. Finite tree recognizers	9
6. Regular tree grammars	14
7. Tree language operations and closure properties of Rec	15
8. Local tree languages.....	19
9. A Kleene theorem for tree languages	20
10. Regular tree systems	22
11. Algebraic characterizations of recognizability	24
12. Monadic second-order logic and regular tree languages	27
13. Families of special regular tree languages.....	29
14. The yield-function and context-free languages	31
15. Context-free tree grammars and pushdown tree recognizers	35
16. Tree transformations and tree transducers.....	38
17. Composition and decomposition of tree transformations.....	42
18. Tree transducers with regular look-ahead.....	43
19. Generalized syntax directed translations	44
20. Surface tree languages	45
21. The hierarchies of surface tree languages and transformational languages	49
22. Some further topics	56
References	61
Chapter 2. Tree-Adjoining Grammars	
<i>Aravind K. Joshi and Yves Schabes</i>	69
1. Introduction.....	69
2. Tree-adjoining grammars.....	70
2.1 Adjoining constraints.....	72
2.2 Derivation in TAG	74
2.3 Some properties of the string languages and tree sets	76
3. Lexicalized grammars.....	79
4. ‘Lexicalization’ of CFGs	81
4.1 Substitution and lexicalization of CFGs	82
4.2 Lexicalization of CFGs with TAGs	86

5. Closure of TAGs under lexicalization	89
6. Summary of lexicalization	90
7. Embedded push-down automaton (EPDA)	91
7.1 Crossed dependencies	93
8. Linguistic relevance	95
9. Some variants of TAGs	101
9.1 Feature structure based TAGs	101
9.2 Synchronous TAGs	101
9.3 Probabilistic LTAGs	101
9.4 Using description trees in TAG	102
9.5 Muti-component TAGs (MCTAG)	102
10. Parsing lexicalized tree-adjoining grammars (LTAG)	102
10.1 Left to right parsing of TAGs	103
10.2 The algorithm	111
10.3 An example	111
10.4 Implementation	114
10.5 Complexity	114
10.6 The parser	115
10.7 Parsing substitution	115
10.8 The valid prefix property and parsing of tree-adjoining grammar	116
11. Summary	120
References	120

Chapter 3. Context-Free Graph Grammars

<i>Joost Engelfriet</i>	125
1. Introduction	125
2. Node and edge replacement	126
3. Hyperedge replacement grammars	130
3.1 Definitions and examples	130
3.2 Normal forms	152
3.3 Subclasses	157
4. Node replacement grammars	165
4.1 Definitions and examples	165
4.2 Subclasses and normal forms	177
4.3 Comparison of HR and NR	181
5. Monadic second order logic	188
6. Graph grammars generating strings and trees	196
7. Tree grammars generating graphs	202
References	208

Chapter 4. Two-Dimensional Languages

<i>Dora Giammarresi and Antonio Restivo</i>	215
1. Introduction	215
2. Preliminaries	218
3. Regular expressions	222

4. Automata	224
4.1 Four-way automata	224
4.2 On-line tessellation automata	227
5. Grammars	229
6. Logic formulas	232
7. Tiling systems	234
7.1 Local two-dimensional languages	234
7.2 Tiling recognizable languages	236
7.3 Closure properties	238
7.4 Domino systems	242
7.5 Generalizations of local languages	246
8. Equivalence theorems	247
8.1 Tiling systems and automata	247
8.2 Tiling systems and logic formulas	249
8.3 Tiling systems and regular expressions	251
8.4 Comparing all families	253
9. Properties of recognizable languages	254
9.1 Necessary conditions for recognizability	254
9.2 Undecidability results	256
10. Recognizable functions	258
11. Beyond finite state recognizability	263
References	265

Chapter 5. Basics of Term Rewriting

<i>Matthias Jantzen</i>	269
1. Introduction	269
2. Terms	270
3. Church–Rosser properties	280
4. Orderings	284
5. Completion	295
6. Rewriting modulo a relation	302
7. Sundries	311
References and further reading	313

Chapter 6. ω -Languages

<i>Ludwig Staiger</i>	339
1. Introduction	339
2. Topology for languages and ω -languages	341
2.1 Cantor topology	341
2.2 Continuous mappings	343
2.3 Wadge’s hierarchy	345
2.4 Joint topologies on $X^* \cup X^\omega$	346
3. The Chomsky hierarchy of ω -languages	348
3.1 Acceptance of ω -languages by automata	348
3.2 Finite automata and regular ω -languages	353
3.3 Context-free ω -languages	356
3.4 ω -languages accepted by Turing machines	361

4. Languages and ω -languages	368
4.1 ω -Kleene closure	368
4.2 ω -power languages	370
4.3 a -transducers, gsm-mappings, and ω -transductions	372
4.4 Limit-closure	375
5. Wagner's hierarchy	378
5.1 Wagner classes	378
5.2 gsm-reducibility	381
References	383

Chapter 7. Languages, Automata, and Logic

<i>Wolfgang Thomas</i>	389
1. Introduction	389
2. Models and formulas	390
2.1 Words, trees, and graphs as models	391
2.2 First-order logic	393
2.3 Monadic second-order logic	395
3. Automata and MSO-logic on finite words and trees	396
3.1 MSO-logic on words	396
3.2 MSO-logic on traces and trees	401
4. First-order definability	405
4.1 The Ehrenfeucht–Fraïssé game	405
4.2 Locally threshold testable sets	409
4.3 Star-free languages	412
5. Automata and MSO-logic on infinite words	415
5.1 ω -automata	416
5.2 Determinization of ω -automata	419
5.3 Applications to definability and decision problems	425
6. Automata and MSO-logic on infinite trees	431
6.1 Automata on infinite trees	431
6.2 Determinacy and complementation	435
6.3 Applications to decision problems of MSO-logic	444
References	449

Chapter 8. Partial Commutation and Traces

<i>Volker Diekert and Yves Métivier</i>	457
1. Introduction	457
2. Free partially commutative monoids	458
2.1 First definitions and basic properties	458
2.2 Projection techniques and Levi's lemma	461
2.3 Normal forms	463
2.4 A simple algorithm to compute normal forms	465
2.5 Möbius functions and normal forms	465
2.6 Bibliographical remarks	470
3. Combinatorial properties	470
3.1 Equations	470
3.2 Strong homomorphisms and codings	473

3.3	Trace codes	476
3.4	Bibliographical remarks	477
4.	Recognizable trace languages	478
4.1	Basic facts about recognizable and rational sets	478
4.2	Recognizability and rational operations	479
4.3	The rank	480
4.4	Recognizability and the lexicographic normal form	483
4.5	The star problem and the finite power property	484
4.6	An algorithm to compute closures	487
4.7	Bibliographical remarks	492
5.	Rational trace languages	492
5.1	Unambiguous languages	492
5.2	Decidability results	494
5.3	Bibliographical remarks	496
6.	Dependence graphs and logic	497
6.1	Dependence graphs	497
6.2	Traces and logic	500
6.3	Ehrenfeucht–Fraïssé games	503
6.4	Bibliographical remarks	506
7.	Asynchronous automata	506
7.1	Zielonka’s theorem	506
7.2	Asynchronous cellular automata	508
7.3	Changing concurrent-read to exclusive-read	508
7.4	Changing exclusive-write to owner-write	509
7.5	The construction for triangulated dependence alphabets	510
7.6	Bounded time-stamps in a distributed system	512
7.7	Bibliographical remarks	516
8.	Infinite traces	516
8.1	Real traces	516
8.2	Asynchronous Büchi and Muller automata	520
8.3	Complex traces	521
8.4	Topological properties and the domain of δ -traces	523
8.5	Bibliographical remarks and further reading	526
	References	527

Chapter 9. Visual Models of Plant Development

	<i>Przemysław Prusinkiewicz, Mark Hammel,</i>	
	<i>Jim Hanan, and Radomír Měch</i>	535
1.	Introduction	535
2.	Developmental models of plant architecture	536
2.1	The modular structure of plants	536
2.2	Plant development as a rewriting process	538
3.	Formal description of branching structures	540
3.1	Axial trees and bracketed strings	540
3.2	The bracketed string notation	541
3.3	The turtle interpretation of bracketed strings	542

- 4. Fundamentals of modeling using L-systems 546
 - 4.1 Parametric D0L-systems 546
 - 4.2 Examples of parametric D0L-system models 548
 - 4.2.1 Fractal generation 549
 - 4.2.2 Simulation of development 549
 - 4.2.3 Exploration of parameter space 550
 - 4.2.4 Modeling mesotonic and acrotonic structures 552
- 5. Random factors in development 554
 - 5.1 The role of randomness in the description of development 554
 - 5.2 Stochastic 0L-systems 554
 - 5.3 A stochastic tree model 556
- 6. Life, death, and reproduction 558
 - 6.1 Non-propagating L-systems 558
 - 6.2 L-systems with a cut symbol 559
 - 6.3 Fragmentation 560
- 7. Development controlled by endogenous mechanisms 562
 - 7.1 Information flow in growing plants 562
 - 7.2 Context-sensitive L-systems 563
 - 7.3 Examples 566
 - 7.3.1 Development of a mesotonic structure 567
 - 7.3.2 Attack of a plant by an insect 568
 - 7.3.3 Development controlled by resource allocation 570
- 8. Development controlled by exogenous mechanisms 576
 - 8.1 Plants and their environment 576
 - 8.2 Environmentally-sensitive L-systems 577
 - 8.3 Examples 579
 - 8.3.1 A deterministic model of plant response to pruning 579
 - 8.3.2 A stochastic model of tree response to pruning 580
 - 8.3.3 Plant climbing 583
 - 8.3.4 Directional cues in development 583
- 9. Conclusions 587
- 10. Acknowledgements 590
- References 591

Chapter 10. Digital Images and Formal Languages

- Karel Culik II and Jarkko Kari* 599
 - 1. Introduction 599
 - 2. Black and white images and finite automata 600
 - 3. Grayscale images and WFA 603
 - 4. Weighted finite transducers 609
 - 5. Examples of WFT 614
- References 615
- Index** 617

Authors' Addresses

Karel Culik II

Department of Computer Science, University of South Carolina
Columbia, SC 29208, U.S.A.

culik@cs.scarolina.edu

Volker Diekert

Institut für Informatik, Universität Stuttgart
Breitwiesenstraße 20-22, D-70565 Stuttgart, Germany
diekert@informatik.uni-stuttgart.de

Joost Engelfriet

Department of Computer Science, Leiden University
P.O. Box 9512, NL-2300 RA Leiden, The Netherlands
engelfri@wi.leidenuniv.nl

Ferenc Gécseg

Department of Informatics, József Attila University
Aradi vértanúk tere 1, H-6720 Szeged, Hungary
gecseg@inf.u-szeged.hu

Dora Giammarresi

Dipartimento di Matematica, Applicata e Informatica,
Università Cu' Foscari di Venezia
Via Torino 155, I-30173 Venezia Mestre, Italy
dora@dsi.unive.it

Mark Hammel

Department of Computer Science, The University of Calgary
2500 University Drive N.W., Calgary, Alberta T2N 1N4, Canada
hammel@cpsc.ucalgary.ca

Jim Hanan

Cooperative Research Centre for Tropical Pest Management
CSIRO Long Pocket Laboratories
Private Bag # 3, Indooroopilly, Queensland, Australia 4068
jim@ctpm.uq.edu.au

Matthias Jantzen

Fachbereich Informatik, Universität Hamburg
Vogt-Kölln-Straße 30, D-22527 Hamburg, Germany
jantzen@informatik.uni-hamburg.de

Aravind K. Joshi

Department of Computer and Information Science and
The Institute for Research in Cognitive Science
The Moore School of Electrical Engineering, University of Pennsylvania
Philadelphia, PA 19104, U.S.A.
joshi@linc.cis.upenn.edu

Jarkko Kari
Department of Computer Science, University of Iowa
101E MacLean Hall, Iowa City, IA 52242-1419, U.S.A.
jjkari@cs.uiowa.edu

Radomír Měch
Department of Computer Science, The University of Calgary
2500 University Drive N.W., Calgary, Alberta T2N 1N4, Canada
mech@cpsc.ucalgary.ca

Yves Métivier
laBRI, Université de Bordeaux I, ENSERB
351 cours de la Libération, F-33405 Talence, France
metivier@labri.u-bordeaux.fr

Przemyslaw Prusinkiewicz
Department of Computer Science, The University of Calgary
2500 University Drive N.W., Calgary, Alberta T2N 1N4, Canada
pwp@cpsc.ucalgary.ca

Antonio Restivo
Dipartimento di Matematica ed Applicazioni, Università di Palermo
Via Archirafi 34, I-90123 Palermo, Italy
restivo@altair.math.unipa.it

Yves Schabes
Mitsubishi Electric Research Laboratories, Cambridge Research Center
201 Broadway, Cambridge, MA 02139, U.S.A.
schabes@merl.com

Ludwig Staiger
Institut für Informatik der
Martin-Luther-Universität Halle-Wittenberg
Kurt-Mothes-Straße 1, D-06099 Halle (Saale), Germany
staiger@informatik.uni-halle.de

Magnus Steinby
Department of Mathematics, University of Turku
FIN-0014 Turku, Finland
steinby@sara.utu.fi

Wolfgang Thomas
Institut für Informatik und Praktische Mathematik, Universität Kiel
Olshausenstraße 40, D-24098 Kiel, Germany
wt@informatik.uni-kiel.de

Handbook of Formal Languages

Volume 3 Beyond Words

Rozenberg, G.; Salomaa, A. (Eds.)

1997, XX, 625 p., Hardcover

ISBN: 978-3-540-60649-9