

Contents of Volume 2

Chapter 1. **Complexity: A Language-Theoretic Point of View**
Cristian Calude and Juraj Hromkovič 1

1. Introduction 1

2. Theory of computation 3

 2.1 Computing fallibilities 3

 2.2 Turing machines, Chaitin computers, and Chomsky grammars . 7

 2.3 Universality 8

 2.4 Silencing a universal computer 11

 2.5 Digression: A simple grammatical model of brain behaviour ... 12

 2.6 The halting problem 13

 2.7 The Church–Turing Thesis 14

 2.8 Digression: mind, brain, and computers 15

3. Computational complexity measures and complexity classes 16

 3.1 Time and space complexities and their properties 16

 3.2 Classification of problems according to computational difficulty
 and nondeterminism 25

 3.3 Hard problems and probabilistic computations 31

4. Program-size complexity 36

 4.1 Dynamic versus program-size complexities 36

 4.2 The halting problem revisited 38

 4.3 Random strings 39

 4.4 From random to regular languages 41

 4.5 Trade-offs 45

 4.6 More about $P \stackrel{?}{=} NP$ 46

5. Parallelism 47

 5.1 Parallel computation thesis and alternation 47

 5.2 Limits to parallel computation and P -completeness 51

 5.3 Communication in parallel and distributive computing 52

References 54

Chapter 2. **Parsing of Context-Free Languages**
Klaas Sikkel and Anton Nijholt 61

1. Introduction 61

 1.1 Parsing algorithms 62

 1.2 Parsing technology 63

 1.3 About this chapter 64

2. An informal introduction 66

3. Parsing schemata	70
3.1 Parsing systems.....	70
3.2 Parsing schemata	71
3.3 Correctness of parsing schemata	72
4. Generalization	74
4.1 Some examples	74
4.2 Formalization	75
4.3 Properties of generalization	77
5. Filtering	79
5.1 Static filtering	79
5.2 Dynamic filtering	80
5.3 Step contraction	82
5.4 Properties of filtering relations	83
6. Some larger examples.....	83
6.1 Left-corner parsing	84
6.2 De Vreught and Honig's algorithm	86
6.3 Rytter's algorithm	90
6.4 Some general remarks	92
7. From schemata to algorithms	93
8. Beyond context-free grammars	96
9. Conclusions	97
References	97

Chapter 3. Grammars with Controlled Derivations

<i>Jürgen Dassow, Gheorghe Păun, and Arto Salomaa</i>	101
1. Introduction and notations	101
2. Some types of controlled derivations and their power	103
2.1 Prescribed sequences	103
2.2 Control by context conditions	115
2.3 Grammars with partial parallelism	124
2.4 Indexed grammars	134
2.5 Hierarchies of families with controlled derivations	135
3. Basic properties	139
3.1 Operations on language families	139
3.2 Decision problems.....	141
3.3 Descriptive complexity	145
4. Further topics	148
References	150

Chapter 4. Grammar Systems

<i>Jürgen Dassow, Gheorghe Păun, and Grzegorz Rozenberg</i>	155
1. Introduction.....	155
2. Formal language prerequisites	157
3. CD grammar systems.....	158
3.1 Definitions	158

3.2	Examples	160
3.3	On the generative capacity	162
3.4	Hybrid systems	164
3.5	Increasing the power by teams	167
3.6	Descriptive complexity	169
3.7	Other classes of CD grammar systems	172
4.	PC grammar systems	173
4.1	Definitions	173
4.2	Examples	177
4.3	On the generative capacity	180
4.4	The context-sensitive case	184
4.5	Non-synchronized PC grammar systems	185
4.6	Descriptive and communication complexity	186
4.7	PC grammar systems with communication by command	189
4.8	Further variants and results	194
5.	Related models	196
5.1	Eco-grammar systems	196
5.2	Test tube systems	201
	References	207

Chapter 5. Contextual Grammars and Natural Languages

<i>Solomon Marcus</i>	215
The year 1957: two complementary strategies	215
The origin of contextual grammars	216
Motivation of simple contextual grammars and of contextual grammars with choice	216
The duality between strings and contexts and the Sestier closure	218
Steps in modelling morphological categories	219
The contextual approach in a generative perspective	221
Contextual grammars can generate both strings and contexts	223
Interplay of strings, contexts and contextual grammars with choice	225
Going deeper in the interplay strings-contexts	227
A higher level of abstraction: parts of speech	228
Generative power of contextual grammars	229
Further suggestions: restricted contextual grammars, grammar systems and splicing contextual schemes	230
References	232

Chapter 6. Contextual Grammars and Formal Languages

<i>Andrzej Ehrenfeucht, Gheorghe Păun, and Grzegorz Rozenberg</i>	237
1. Introduction	237
2. Contextual grammars with unrestricted choice	238
2.1 Preliminaries	238
2.2 Definitions	238

2.3	Examples	241
2.4	Necessary conditions and counterexamples	243
2.5	Generative capacity	247
2.6	Closure properties	249
2.7	Decidability properties	253
3.	Contextual grammars with restricted choice	256
3.1	Definitions and basic results	256
3.2	Internal contextual grammars with finite choice	261
3.3	External contextual grammars with regular choice	264
4.	Variants of contextual grammars	275
4.1	Deterministic grammars	275
4.2	One-sided contexts	277
4.3	Leftmost derivation	281
4.4	Parallel derivation	282
4.5	Maximal/minimal use of selectors	284
5.	Bibliographical notes	285
	References	290

Chapter 7. Language Theory and Molecular Genetics

	<i>Thomas Head, Gheorghe Păun, and Dennis Pixton</i>	295
1.	Introduction	295
2.	Formal language theory prerequisites	298
3.	The splicing operation	298
3.1	The uniterated case	298
3.2	The iterated case	306
3.3	The case of multisets	319
4.	Generative mechanisms based on splicing	325
4.1	Simple H systems	326
4.2	Extended H systems	333
5.	Splicing circular words	335
5.1	Circular words	335
5.2	Circular splicing	336
5.3	Mixed splicing	342
6.	Computing by splicing	344
7.	Bibliographical notes	348
	Appendix	351
	References	358

Chapter 8. String Editing and Longest Common Subsequences

	<i>Alberto Apostolico</i>	361
1.	Introduction	361
1.1	Approximate string searching	363
1.2	Local similarity searches in DNA and protein sequences	363
1.3	Longest common subsequences	364

2.	Two basic paradigms for the LCS problem	366
2.1	Hirschberg's paradigm: finding antichains one at a time	368
2.2	Incremental antichain decompositions and the Hunt-Szymanski paradigm	371
3.	A speed-up for HS	372
4.	Finger trees	375
5.	Linear space	379
5.1	Computing the length of a solution	380
5.2	Computing an LCS in $O(n(m-l))$ time and linear space	382
6.	Combining few and diverse tools: Hirschberg's paradigm in linear space	386
7.	Parallel algorithms	389
	References	395

Chapter 9. Automata for Matching Patterns

	<i>Maxime Crochemore and Christophe Hancart</i>	399
1.	Pattern matching and automata	399
2.	Notations	400
2.1	Alphabet and words	401
2.2	Languages	401
2.3	Regular expressions	401
2.4	Finite automata	402
2.5	Algorithms for matching patterns	403
3.	Representations of deterministic automata	405
3.1	Transition matrix	405
3.2	Adjacency lists	406
3.3	Transition list	407
3.4	Failure function	407
3.5	Table-compression	408
4.	Matching regular expressions	408
4.1	Outline	408
4.2	Regular-expression-matching automata	409
4.3	Searching with regular-expression-matching automata	411
4.4	Time-space trade-off	414
5.	Matching finite sets of words	414
5.1	Outline	414
5.2	Dictionary-matching automata	415
5.3	Linear dictionary-matching automata	416
5.4	Searching with linear dictionary-matching automata	420
6.	Matching words	422
6.1	Outline	422
6.2	String-matching automata	423
6.3	Linear string-matching automata	426
6.4	Properties of string-matching automata	428
6.5	Searching with linear string-matching automata	431

7. Suffix automata.....	434
7.1 Outline	434
7.2 Sizes and properties	435
7.2.1 End-positions	435
7.2.2 Suffix function	436
7.2.3 State splitting	437
7.2.4 Sizes of suffix automata	439
7.3 Construction	441
7.3.1 Suffix links and suffix paths	441
7.3.2 On-line construction	442
7.3.3 Complexity	446
7.4 As indexes	447
7.4.1 Membership	448
7.4.2 First position	448
7.4.3 Occurrence number	449
7.4.4 List of positions	450
7.4.5 Longest repeated factor	450
7.5 As string-matching automata	451
7.5.1 Ending factors	451
7.5.2 Optimization of suffix links	452
7.5.3 Searching for rotations	453
7.6 Factor automata	454
7.6.1 Relation to suffix automata	454
7.6.2 Size of factor automata	455
7.6.3 On-line construction	456
Bibliographic notes	459
References	461

Chapter 10. Symbolic Dynamics and Finite Automata

<i>Marie-Pierre Béal and Dominique Perrin</i>	463
1. Introduction	463
2. Symbolic dynamical systems	464
3. Recurrence and minimality	470
4. Sofic systems and shifts of finite type	472
5. Minimal automaton of a subshift	477
6. Codes and finite-to-one maps	480
7. State splitting and merging	484
8. Shift equivalence	487
9. Entropy	490
10. The road coloring problem	496
11. The zeta function of a subshift	498
12. Circular codes, shifts of finite type and Krieger embedding theorem	500
References	503

Chapter 11. Cryptology: Language-Theoretic Aspects	
<i>Valtteri Niemi</i>	507
1. Introduction	507
2. Basic notions in cryptology	507
3. Connections between cryptology and language theory	510
4. Public-key systems based on language theory	511
4.1 Wagner-Magyarik system	511
4.2 Salomaa-Welzl system	512
4.3 Subramanian et al. system	513
4.4 Siromoney-Mathew system	514
4.5 Niemi system	514
4.6 Oleshchuk system	515
5. Cryptosystems based on automata theory	516
5.1 Wolfram system	516
5.2 Guan public-key system	516
5.3 Tao-Chen public-key system	517
6. Theoretical cryptologic research based on language theory	518
7. Cryptanalysis based on language theory	519
8. Language-theoretic research inspired by cryptology	520
9. Research associated with language theory and cryptology	521
References	521
Index	525

Authors' Addresses

Alberto Apostolico

Dipartimento di Elettronica e Informatica, Università di Padova

Via Gradenigo 6/a, I-35131 Padova, Italy

and Department of Computer Science, Purdue University

1398 Computer Science Building, West Lafayette, IN 47907-1398, U.S.A.

axa@cs.purdue.edu

Marie-Pierre Béal

Institut Gaspard Monge, Université de Marne-la-Vallée

2, rue de la Butte verte, F-93166 Noisy-le-Grand, France

beal@monge.univ-mlv.fr

Cristian Calude

Centre for Discrete Mathematics and Theoretical Computer Science

The University of Auckland, Private Bag 92019, Auckland, New Zealand

c.calude@cs.aukuni.ac.nz

Maxime Crochemore

Institut Gaspard Monge, Université de Marne-la-Vallée

2, rue de la Butte verte, F-93166 Noisy-le-Grand, France

mac@univ-mlv.fr

Jürgen Dassow

Faculty of Computer Science, Otto-von-Guericke-University of Magdeburg

P.O. Box 4120, D-39016 Magdeburg, Germany

dassow@cs.uni-magdeburg.de

Andrzej Ehrenfeucht

Department of Computer Science, University of Colorado at Boulder

Campus 430, Boulder, CO 80309, U.S.A.

andrzej@piper.cs.colorado.edu

Christophe Hancart

Laboratoire d'Informatique de Rouen, Faculté des Sciences et Techniques

Université de Rouen, F-76821 Mont-Saint-Aignan Cedex, France

hancart@dir.univ-rouen.fr

Thomas Head

Department of Mathematics, University of Binghamton

P.O. Box 6000, Binghamton, NY 13902, U.S.A.

tom@math.binghamton.edu

Juraj Hromkovič

Institut für Informatik und Praktische Mathematik, Universität Kiel
Olshausenstrasse 40, D-24098 Kiel, Germany
jhr@informatik.uni-kiel.d400.de

Solomon Marcus

Faculty of Mathematics, University of Bucharest
Str. Academiei, RO-70109 Bucharest, Romania
solomon@imar.ro

Valtteri Niemi

Department of Mathematics and Statistics, University of Vaasa
FIN-65101 Vaasa, Finland
vni@uwasa.fi

Anton Nijholt

Computer Science Department, University of Twente
P.O. Box 217, NL-7500 AE Enschede, The Netherlands
anijholt@cs.utwente.nl

Gheorghe Păun

Institute of Mathematics of the Romanian Academy
P.O. Box 1-764, RO-70700 Bucharest, Romania
gpaun@imar.ro

Dominique Perrin

Institut Gaspard Monge, Université de Marne-la-Vallée
2, rue de la Butte verte, F-93166 Noisy-le-Grand, France
perrin@univ-mlv.fr

Dennis Pixton

Department of Mathematics, University of Binghamton
P.O. Box 6000, Binghamton, New York 13902, U.S.A.
dennis@math.binghamton.edu

Grzegorz Rozenberg

Department of Computer Science, Leiden University
P.O. Box 9512, NL-2300 RA Leiden, The Netherlands
and Department of Computer Science, University of Colorado at Boulder
Campus 430, Boulder, CO 80309, U.S.A.
rozenber@wi.leidenuniv.nl

Arto Salomaa

Academy of Finland and Turku Centre for Computer Science (TUCS)
Lemminkäisenkatu 14 A, FIN-20520 Turku, Finland
asalomaa@sara.cc.utu.fi

Klaas Sikkel

FIT, CSCW, German National Research Centre for Information Technology (GMD)
Schloß Birlinghoven, D-53757 Sankt Augustin, Germany
sikkel@gmd.de

Handbook of Formal Languages

Volume 2. Linear Modeling: Background and Application

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

1997, XXII, 528 p., Hardcover

ISBN: 978-3-540-60648-2