

# Contents

## VOLUME ONE

Preface	vii
List of contributors	xvii

### Part I Foundations

Chapter 1	
<b>Finite automata</b>	3
<i>Jean-Éric Pin</i>	
Chapter 2	
<b>Automata and rational expressions</b>	39
<i>Jacques Sakarovitch</i>	
Chapter 3	
<b>Finite transducers and rational transductions</b>	79
<i>Tero Harju and Juhani Karhumäki</i>	
Chapter 4	
<b>Weighted automata</b>	113
<i>Manfred Droste and Dietrich Kuske</i>	
Chapter 5	
<b>Max-plus automata</b>	151
<i>Sylvain Lombardy and Jean Mairesse</i>	
Chapter 6	
<b><math>\omega</math>-Automata</b>	189
<i>Thomas Wilke (revised by Sven Schewe)</i>	
Chapter 7	
<b>Automata on finite trees</b>	235
<i>Christof Löding and Wolfgang Thomas</i>	

Chapter 8	
<b>Automata on infinite trees</b>	265
<i>Christof Löding</i>	

Chapter 9	
<b>Two-dimensional models</b>	303
<i>Stefano Crespi Reghizzi, Dora Giammarresi, and Violetta Lonati</i>	

**Part II**  
**Complexity issues**

Chapter 10	
<b>Minimisation of automata</b>	337
<i>Jean Berstel, Luc Boasson, Olivier Carton, and Isabelle Fagnot</i>	

Chapter 11	
<b>Learning algorithms</b>	375
<i>Henrik Björklund, Johanna Björklund, and Wim Martens</i>	

Chapter 12	
<b>Descriptional complexity of regular languages</b>	411
<i>Hermann Gruber, Markus Holzer, and Martin Kutrib</i>	

Chapter 13	
<b>Enumerating regular expressions and their languages</b>	459
<i>Hermann Gruber, Jonathan Lee, and Jeffrey Shallit</i>	

Chapter 14	
<b>Circuit complexity of regular languages</b>	493
<i>Michal Koucký</i>	

Chapter 15	
<b>Černý's conjecture and the road colouring problem</b>	525
<i>Jarkko Kari and Mikhail Volkov</i>	

Part III  
**Algebraic and topological theory of automata**

Chapter 16	
<b>Varieties</b>	569
<i>Howard Straubing and Pascal Weil</i>	
Chapter 17	
<b>Profinite topologies</b>	615
<i>Jorge Almeida and Alfredo Costa</i>	
Chapter 18	
<b>The factorisation forest theorem</b>	653
<i>Thomas Colcombet</i>	
Chapter 19	
<b>Wadge–Wagner hierarchies</b>	695
<i>Jacques Duparc</i>	
Chapter 20	
<b>Equational theories for automata</b>	729
<i>Zoltán Ésik</i>	
Chapter 21	
<b>Language equations</b>	765
<i>Michał Kunc and Alexander Okhotin</i>	
Chapter 22	
<b>Algebra for trees</b>	801
<i>Mikołaj Bojańczyk</i>	
Index	xxiii

**VOLUME TWO**

Preface	VII
List of contributors	XVII

**Part IV  
Automata in mathematics**

Chapter 23	
<b>Rational subsets of groups</b>	841
<i>Laurent Bartholdi and Pedro V. Silva</i>	
Chapter 24	
<b>Groups defined by automata</b>	871
<i>Laurent Bartholdi and Pedro V. Silva</i>	
Chapter 25	
<b>Automata in number theory</b>	913
<i>Boris Adamczewski and Jason Bell</i>	
Chapter 26	
<b>On Cobham's theorem</b>	947
<i>Fabien Durand and Michel Rigo</i>	
Chapter 27	
<b>Symbolic dynamics</b>	987
<i>Marie-Pierre Béal, Jean Berstel, Søren Eilers, and Dominique Perrin</i>	
Chapter 28	
<b>Automatic structures</b>	1031
<i>Sasha Rubin</i>	
Chapter 29	
<b>Automata and finite model theory</b>	1071
<i>Wouter Gelade and Thomas Schwentick</i>	
Chapter 30	
<b>Finite automata, image manipulation, and automatic real functions</b>	1105
<i>Juhani Karhumäki and Jarkko Kari</i>	

Part V  
**Selected applications**

Chapter 31	
<b>Communicating automata</b>	1147
<i>Dietrich Kuske and Anca Muscholl</i>	
Chapter 32	
<b>Symbolic methods and automata</b>	1189
<i>Bernard Boigelot</i>	
Chapter 33	
<b>Synthesis with finite automata</b>	1217
<i>Igor Walukiewicz</i>	
Chapter 34	
<b>Timed automata</b>	1261
<i>Patricia Bouyer</i>	
Chapter 35	
<b>Higher-order recursion schemes and their automata models</b>	1295
<i>Arnaud Carayol and Olivier Serre</i>	
Chapter 36	
<b>Analysis of probabilistic processes and automata theory</b>	1343
<i>Kousha Etessami</i>	
Chapter 37	
<b>Natural language parsing</b>	1383
<i>Mark-Jan Nederhof and Giorgio Satta</i>	
Chapter 38	
<b>Verification</b>	1415
<i>Javier Esparza, Orna Kupferman, and Moshe Y. Vardi</i>	
Chapter 39	
<b>Automata and quantum computing</b>	1457
<i>Andris Ambainis and Abuzer Yakaryilmaz</i>	
Index	xxiii
Index	xxiii