

# Contents

## VOLUME ONE

Preface	VII
List of contributors	XVII

### Part I Foundations

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

Chapter 8  
**Automata on infinite trees** 265  
*Christof Löding*

Chapter 9  
**Two-dimensional models** 303  
*Stefano Crespi Reghizzi, Dora Giammarresi, and Violetta Lonati*

Part II  
**Complexity issues**

Chapter 10  
**Minimisation of automata** 337  
*Jean Berstel, Luc Boasson, Olivier Carton, and Isabelle Fagnot*

Chapter 11  
**Learning algorithms** 375  
*Henrik Björklund, Johanna Björklund, and Wim Martens*

Chapter 12  
**Descriptive complexity of regular languages** 411  
*Hermann Gruber, Markus Holzer, and Martin Kutrib*

Chapter 13  
**Enumerating regular expressions and their languages** 459  
*Hermann Gruber, Jonathan Lee, and Jeffrey Shallit*

Chapter 14  
**Circuit complexity of regular languages** 493  
*Michal Koucký*

Chapter 15  
**Černý's conjecture and the road colouring problem** 525  
*Jarkko Kari and Mikhail Volkov*

## 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>Michal 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