

**AUTOMATA 2009**

15<sup>th</sup> International Workshop on  
Cellular Automata and  
Discrete Complex Systems

**AUTOMATA 2009**

**AUTOMATA 2009**

**Editors:**  
Pedro P.B. de Oliveira & Jarkko Kari

ISBN-10: 1-905986-21-1  
ISBN-13: 978-1-905986-21-7



**Mackenzie**

PROCEEDINGS

---

---

15<sup>th</sup> INTERNATIONAL WORKSHOP ON  
CELLULAR AUTOMATA AND DISCRETE COMPLEX SYSTEMS  
**AUTOMATA 2009**

São José dos Campos, SP, Brazil

October 10-12, 2009

---

Editors:

PEDRO P.B. DE OLIVEIRA & JARKKO KARI

---

AUTOMATA-2009

Copyright © Elsevier B.V. 2009 (the papers from Part 1)  
Copyright © The Respective Authors (the papers from Part 2)

All rights reserved. This book, or parts thereof, may not be reproduced in any form or by any means, electronic or mechanical, including photocopying, recording or by any information storage and retrieval system, without permission in writing from the copyright holders.

While every attempt is made to ensure that the information in this publication is correct, no liability can be accepted by the authors or publishers for loss, damage or injury caused by any errors in, or omission from, the information given.

*Background cover image:* Temporal evolution of a binary, one-dimensional cellular automaton rule with efficacy of 86.9% for density classification, on a lattice size of 800 cells, with more 1s than 0s. Image generated by Dietmar Wolz.

Citation:

In Pedro P.B. de Oliveira & Jarkko Kari, editors. *Proceedings of Automata 2009: 15th International Workshop on Cellular Automata and Discrete Complex Systems*, Universidade Presbiteriana Mackenzie, São Paulo, SP, Brazil, 2009.

ISBN-10: 1-905986-21-1

ISBN-13: 978-1-905986-21-7

Local proceedings printed by Alphagraphics, on behalf of the host/organising institution: Universidade Presbiteriana Mackenzie, São Paulo, SP, Brazil.



## Contents

<b>Preface</b>	vii
<b>Index</b>	356
<b>Index of Authors</b>	358
PART 1: FULL PAPERS	
MAURICE MARGENSTERN	
About the Garden of Eden theorems for cellular automata in the hyperbolic plane .....	1
PATRICK EDIGER & ROLF HOFFMANN	
CA models for target searching agents .....	10
RUBENS A. ZIMBRES & PEDRO P.B. DE OLIVEIRA	
Dynamics of quality perception in a social network: A cellular automaton based model in aesthetics services .....	23
SUKANTA DAS, SUKANYA MUKHERJEE, NAZMA NASKAR & BIPLAB K. SIKDAR	
Characterization of single cycle <i>CA</i> and its application in pattern classification .....	46
SUKANTA DAS & BIPLAB K. SIKDAR	
Characterization of 1-d periodic boundary reversible <i>CA</i> .....	68
KELLIE M. EVANS	
Larger than life's invariant measures .....	93
HEATHER BETEL & PAOLA FLOCCHINI	
On the relationship between boolean and fuzzy cellular automata .....	113
HEATHER BETEL & PAOLA FLOCCHINI	
On the asymptotic behavior of fuzzy cellular automata .....	129
J. ANDRÉS MONTOYA & CAROLINA MEJÍA	
On the complexity of sandpile prediction problems .....	147
JAN PODROUZEK	
Stochastic cellular automata in dynamic environmental modeling: Practical applications .....	163

MARTIN KUTRIB & ANDREAS MALCHER	
On one-way one-bit $O$ (one)-message cellular automata .....	178
CLAUDIO L.M. MARTINS & PEDRO P.B. DE OLIVEIRA	
Improvement of a result on sequencing elementary cellular automata rules for solving the parity problem .....	192
GINA M. B. OLIVEIRA, LUIZ G. A. MARTINS, LAURA B. DE CARVALHO & ENRIQUE FYNN	
Some investigations about synchronization and density classification tasks in one-dimensional and two-dimensional cellular automata rule spaces .....	209
PART 2: SHORT PAPERS	
ANDRÉS STAUFFER & JOËL ROSSIER	
CA based self-testing and self-organizing configurable circuits .....	231
BURTON VOORHEES	
Analysis of binary valued additive cylindrical cellular automata using roots of unity .....	242
KOHI TOMITA & HARUSHITA KUROKAWA	
Reversibility in graph-rewriting automata .....	252
CHRISTOPHER AUER, PATRICK WÜCHNER & HERMANN DE MEER	
Target-oriented self-structuring in classifying cellular automata .....	260
LEONARDO D. TAVARES, DOUGLAS A.G. VIEIRA, RODNEY R. SALDANHA & WALMIR M. CAMINHAS	
Simulating car accidents with cellular automata traffic flow model ....	272
MICHAL SEREDYNSKI, ROMUALD KOTOWSKI, WOJCIECH MAKA & PASCAL BOUVRY	
Collective behaviour in spatio-temporally generalized prisoner's dilemma .....	282
MIROSLAW SZABAN & FRANCISZEK SEREDYNSKI	
How to design secure S-boxes based on 1D cellular automata .....	291
SILVIO CAPOBIANCO	
Some notes on Besicovitch and Weyl distances over higher-dimensional configurations .....	300
KENICHI MORITA	
Simulating reversible turing machines by 1-dimensional reversible cellular automata .....	309

ERIC GOLES, PIERRE GUILLON & IVAN RAPAPORT	
Traced communication complexity of cellular automata .....	318
EGOR DOLZHENKO & NATAŠA JONOSKA	
CA-generated two-dimensional languages .....	328
ANGELO SCHRANKO & PEDRO P.B. DE OLIVEIRA	
Derivation of one-dimensional, reversible, number-conserving cellular au- tomata rules .....	335
JAN M. BAETENS & BERNARD DE BAETS	
Towards spatial irregularity in cellular automata .....	346

## Preface

**AUTOMATA 2009** is the fifteenth workshop in a series of homonymous events established in 1995 by members of the Working Group 1.5, subordinated to the Technical Committee 1: Foundations of Computer Science, of the International Federation for Information Processing (IFIP). The original Working Group 1.5, denominated Cellular Automata and Machines, was dissolved in early 2004, and during the last couple of years, discussions within the group led to the extension of its original scope, from cellular automata to more general discrete complex systems. In 2008 the Working Group 1.5 was officially reestablished, and **AUTOMATA 2009** will host its first annual meeting in the renewed, updated phase of the group, now denominated Cellular Automata and Discrete Complex Systems, with the following attributions:

- To establish and maintain a permanent, international, multidisciplinary forum for the collaboration of researchers in the fields of Cellular Automata (CAs) and Discrete Complex Systems (DCS).
- To provide a platform for presenting and discussing new ideas and results.
- To support the development of theory and applications of CAs and DCS (e.g. parallel computing, physics, biology, and others) as long as fundamental aspects and their relations are concerned.
- To identify and study within an inter- and multidisciplinary context, the important fundamental aspects, concepts, notions and problems concerning CAs and DCS.

As such, **AUTOMATA 2009** opened up to all fundamental aspects of cellular automata and discrete complex systems, including: dynamics; algebraic aspects; complexity issues; emergent properties; formal language processing; models of parallelism and distributed systems; phenomenological descriptions; scientific modeling; and practical applications.

The workshop had 38 submissions, from 17 countries, and 26 papers have been selected for presentation and to make up this volume. Half of them, the Part 1 of the present volume, have also been published in Elsevier's ENTC, Electronic Notes in Theoretical Computer Science. All together, the papers herein include both well-developed pieces of research as well as work-in-progress and/or exploratory papers, covering four forms of discrete dynamical systems: multi-agent system, sandpile, graph-rewriting automata, and variations of cellular automata, with a clear emphasis on the latter. Among the papers, 6 discuss CA

based applications (in pattern classification, dynamics of social networks, environmental and traffic modelling, micro-circuitry and cryptography), 3 represent conceptual developments on the computational ability of CAs, 3 are concerned with the dynamics and characterisation of non-CA systems (a cellular multi-agent system, a sandpile and graph-rewriting automata), and the remaining 14 papers constitute theoretical accounts on various fronts in CA theory, namely, relations between standard and fuzzy CAs, CAs in non-standard lattices (such as the hyperbolic plane), and various forms of characterisations of CAs, including reversibility, conservativity, communication, complexity measures, language recognition and dynamics. All together, the papers form a very rich sample of the state-of-art advances in discrete dynamical systems

The workshop also counted on six distinguished invited speakers:

- *Eric Goles*, Universidad Adolfo Ibáñez, “Communication Complexity in Cellular Automata”
- *Jarkko Kari*, University of Turku, Finland: “Classical Cellular Automata Theory: A Tutorial”
- *Leon Chua*, University of California, Berkeley, USA: “Cellular Automata for Kids”
- *Martin Kutrib*, Universität Gießen, Germany: “Cellular Automata and Language Theory”
- *Stephen Wolfram* (in videoconference), Wolfram Research, USA: “The History and Promise of Cellular Automata”
- *Vincent Blondel*, Université Catholique de Louvain, Belgium: “Discrete Dynamical Systems and Matrices Products”

It is our satisfaction to acknowledge and thank the efforts of the following international Programme Committee, additional referees, and the institutions that provided the support and means for the

- Alejandro Maass (CL) - University of Chile
- Andreas Deutsch (DE) - Dresden University of Technology
- Andy Adamatzky (UK) - University of the West of England
- Anna Lawniczak (CA) - University of Guelph
- Burton Voorhees (CA) - Athabasca University
- Bruno Durand (FR) - University of Provence
- Danuta Makowiec (PL) - Gdansk University
- Enrico Formenti (FR) - University of Nice-Sophia Antipolis

- Ferdinand Peper (JP) - National Institute of Information and Communication Technology
- Georgios Sirakoulis (GR) - Democritus University of Thrace
- Gianpiero Cattaneo (IT) - University of Milano-Bicocca
- Henryk Fukś (CA) - Brock University
- Hiroshi Umeo (JP) - University of Osaka Electro-Communication
- Jarkko Kari (FI; co-chair) - University of Turku
- Juan Carlos Seck (MX) - Autonomous University of Hidalgo State
- Kenichi Morita (JP) - Hiroshima University
- Klaus Sutner (USA) - Carnegie Mellon University
- Laurent Vuillon (FR) - University of Savoie
- Marco Tomassini (CH) - University of Lausanne
- Martin Kutrib (DE) - University of Gießen
- Maurice Margenstern (FR) - University of Metz
- Nazim Fatès (FR) - LORIA: Lorrain Laboratory for Research in Informatics
- Nicolas Ollinger (FR) - University of Provence
- Pedro de Oliveira (BR; co-chair) - Mackenzie Presbyterian University
- Peter Sloot (NL) - University of Amsterdam
- Pradipta Maji (IN) - Indian Statistical Institute
- Stefania Bandini (IT) - University of Milano-Bicocca
- Thomas Worsch (DE) - University of Karlsruhe

**Additional referees:** Alberto Dennunzio, Pierre Guillon, Katsunobu Imai, Chuzo Iwamoto, Tyll Krüger, Benoît Masson, Gaétan Richard, Andrei Romashchenko, Gustavo Sibona, Bruno Di Stefano and Siamak Taati.

**Organisation:** Universidade Presbiteriana Mackenzie, São Paulo, Brazil

**Under the auspices of:** IFIP - International Federation for Information Processing

**Sponsorship:** Fundo Mackenzie de Pesquisa (MackPesquisa), IFIP, Fibrforte Engenharia, SIA Informática, Wolfram Research, NatComp and Fundação de Amparo à Pesquisa do Estado de São Paulo (FAPESP)

**Support:** Brazilian Computing Society (SBC) and Brazilian Society for Applied and Computational Mathematics (SBMAC)

***Additional thanks:*** Rodrigo Freitas and Daniel Arndt (for their crucial editing help, in the proceedings and the web-page, respectively), Michael Mislove (for his role as Managing Editor of ENTCS), Mike Hinchey (for his decisive support to the event, through IFIP TC-1) and, for their overall support, the members of the steering committee of the workshop (Andy Adamatzky, Anna Lawniczak, Kenichi Morita and Thomas Worsch) and further members of the organisation committee (Luciano Silva, Leandro de Castro, Mauricio Marengoni and Angelo Schranko).

Finally, our sincere thankfulness and deepest respect, to the authors of all submitted papers.

*September 14th, 2009*

*Pedro P.B. de Oliveira & Jarkko Kari*