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Cellular Automata and Discrete Complex Systems

23rd IFIP WG 1.5 International Workshop, AUTOMATA 2017
Milan, Italy, June 7–9, 2017
Proceedings

Springer

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Preface

The 23rd International Workshop on Cellular Automata and Discrete Complex Systems, AUTOMATA 2017, was held in Milan, Italy, during June 7–9, 2017.

It was organized by the Department of Informatics, Systems, and Communication of the University of Milano-Bicocca. The event was an IFIP Working Conference and it hosted the annual meeting of the IFIP Working Group 1.5.

AUTOMATA 2017 continued an annual series of events established in 1995 as a forum for the collaboration between researchers in the field of cellular automata and related discrete complex systems. Over the years, the topics have been progressively expanded. This year the scope was further broadened including new topics concerning correlated models of automata.

Current topics include (but are not limited to) the following aspects and features of such systems: dynamics, topological, ergodic, and algebraic aspects, algorithmic and complexity issues, emergent properties, formal languages, symbolic dynamics, tilings, models of parallelism and distributed systems, timing schemes, synchronous versus asynchronous models, phenomenological descriptions, scientific modelling, and practical applications. The conference attracted a good number of submissions, which indicates a continued interest in these topics.

There were three invited talks at the conference, and we wish to thank the speakers Eric Goles, Adrien Richard, and Ville Salo for accepting the invitation and for their very interesting presentations. The invited contributions are included in this volume.

There were 29 submissions as full papers to the conference. Each submission was managed by two or three Program Committee members. Based on the reviews and discussions, the committee decided to accept 14 papers to be presented at the conference and to be included in the proceedings. We would like to thank all authors for their contributions and work without which this event would not have been possible. The conference program also involved short presentations of exploratory papers that are not included in these proceedings, and we wish to extend our thanks also to the authors of the exploratory submissions.

We are indebted to the Program Committee and the additional reviewers for their valuable help in selecting the papers. We extend our thanks to the remaining member of the local Organizing Committee, Luca Mariot. We are also grateful for the support by the Department of Informatics, Systems and Communication and the University of Milano-Bicocca. Finally, we acknowledge the excellent cooperation from the *Lecture Notes in Computer Science* team of Springer for their help in producing this volume in time for the conference.

April 2017

Alberto Dennunzio
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Abstracts of Invited Talks

Two Dimensional Cellular Automata and Computational Complexity

Eric Goles

Facultad de Tecnología y Ciencias, Universidad Adolfo Ibáñez, Santiago, Chile

Let us consider a two-dimensional automata with states $\{0, 1\}$ and the von Neumann neighborhood. I will present results about the computational complexity of some prediction problems related with the strict majority as well as the class of freezing local functions.

The strict majority function considers the most represented state in its neighborhood. In case of tie the central state remains unchanged. On the other hand, in a freezing local functions the state 1 remains invariant, so dynamics appears only by updating sites in state 0. For the von Neumann neighborhood (considering 0 as a quiescent state) there are 32 rotation invariant local functions, so 16 totalistic ones, i.e., depending only of the sum of the states). In the next table we exhibit the totalistic local rules:

Table 1. Possible rules and their complexity when $0 \notin I$. The ✓ in the i-th column means that the local rule is 1 for that value of the sum.

Rule	$1 \in I$	$2 \in I$	$3 \in I$	$4 \in I$	EventPred	AsyncPred
T					$\mathcal{O}(1)$	$\mathcal{O}(1)$
4				✓	$\mathcal{O}(1)$	$\mathcal{O}(1)$
3			✓		in NC	?
34			✓	✓	in NC	NC
2		✓			P-Complete	?
24		✓		✓	P-Complete	?
23		✓	✓		?	?
234		✓	✓	✓	in NC	NC
1	✓				?	in NC
14	✓			✓	?	in NC
13	✓		✓		?	in NC
134	✓		✓	✓	?	in NC
12	✓	✓			in NC	in NC
124	✓	✓		✓	in NC	in NC
123	✓	✓	✓		in NC	in NC
1234	✓	✓	✓	✓	$\mathcal{O}(1)$	$\mathcal{O}(1)$

To exhibit the non-totalistic but rotation invariant rules, it is enough to differentiate the output when there are exactly two states at value 1:

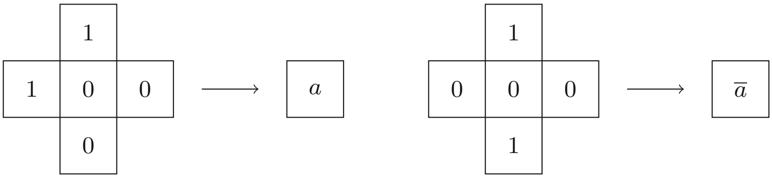

Fig. 1. Non-totalistic update for von Neumann neighborhood. $a \in \{0, 1\}$

For the automaton's dynamics we will consider two update models, synchronous (every site is updated at the same time) and asynchronous: sites are updated one by one in a prescribed order or equivalently following a permutation of the set of sites. In this case, we call the permutation a sequential updating scheme. From that we define the following decision problems:

Eventual-Prediction (EventPred)
Input: A finite configuration x of dimensions $n \times n$ and a site $u \in [n] \times [n]$ such that
$x_u = 0$.
Question: Does there exist $t^* > 0$ such that $(F^{t^*}(x))_u = 1$?

and

Asynchronous-Prediction (AsyncPred)
Input: A finite configuration x of dimensions $n \times n$, a site $u \in [n] \times [n]$ such that $x_u = 0$.
Question: Does there exist a sequential updating scheme σ and $t^* > 0$ such that $(F^{\sigma t^*}(x))_u = 1$.

For some of those problems we will exhibit their computational complexity as well as the tools developed to prove it. Further, for AsyncPred, we proved that the Strict Majority Automata is in *NC*. given an answer to the conjecture proposed by C. Moore.

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Fixed Points in Boolean Networks

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A Boolean network is defined from a finite digraph G by associating to each vertex a binary variable and a local transition function, which depends on in-neighbors' variables. Dynamics are then obtained by applying the local transition functions, synchronously or asynchronously.

Boolean networks have many applications. For instance, they are classical models for gene networks. In this context, the interaction graph G is often known, or at least well approximated, while the actual dynamics are not. A natural question is then the following: *what can be said on the dynamics according to the interaction graph G only?*

In this presentation, we give partial answers, focusing on the maximum number of fixed points and some particular classes of networks, such as monotone networks.

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Contents