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Book Review : Exploring Discrete Dynamics

The Reviewers

Andrew Adamatzky, University of the West of England, Bristol, UK

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A cellular automaton is an array of locally interconnected finite-states machines, called cells, which update their states simultaneously, in discrete time, and by the same rule. Every cell updates its next depending on states of its closest neighbours. Since their invention by Ulam and promotion by von Newman and Zuse, cellular automata became an almost universal “substrate” to simulate complex systems, spatially interacting processes in biological, physical, chemical, and socio-economic systems. Cellular automata are also proved to be an indispensable models of massive-parallel computing architectures, including future and emergent spatially extended non-silicon computers, like reaction-diffusion chemical computers and molecular-layer nano-computers.

Andrew Wuensche is amongst the legends of cellular automata sciences. He is an architect who became a self-taught computer scientist in mid-life. In the late 1980s early 1990s Dr Wuensche developed a unique software environment to experiment and investigate one-dimensional cellular automata. His algorithms for finding pre-images enabling the analysis of global behaviour of cellular automata, and methods for classifying cellular automata dynamics, became commonly-found items in textbooks. Wuensche's first book *The Global Dynamics of Cellular Automata* inspired thousands of young graduates in mathematics, physics, biology, to enter the field of cellular automata and to make myriad amazing discoveries.

In the last 20 years Andrew Wuensche was meticulously perfecting his approach to the analysis of cellular automata, and the more general random Boolean networks, and discrete dynamical networks, enhancing his DDLab software. The results of this work are now published in the book *Exploring Discrete Dynamics*. In over half-a-thousand pages of the book a reader will find unique and exciting ideas, tools, approaches

and implementations towards studying complex systems in a cellular automaton framework.

Before you start reading the book, go to www.ddlab.org and download the Discrete Dynamics Lab software, all concepts in the book are illustrated with this shareware package.

What topics are covered in the book? You will learn how to setup uniform and heterogeneous neighbourhoods, define the rule-table, and wire an arbitrary network of finite-state machines. The types of the cell-transition rules, including totalistic, outer-totalistic, reaction-diffusion, and threshold-based rules, are lavishly illustrated with working examples and non-trivial configurations. Wuensche also provides an interesting approach for rule transformation, for example, mixing of different types of rules, negative, reflective and neutral transformations, canalisation, and Derrida plots.

With regards to the characterisation of automata network behaviour, the book teaches us to construct global state transition graphs, and how to calculate basins of attraction and limit cycles. Our excitement reaches its apogee in 25th chapter. There we meet our good-old friends Langton's λ-parameter, Wuensche's Z-parameter, and G-density.

In further chapters we learn how to implement mutations in attractor basins, calculate pre-images, and analyse space-time configurations. When analysing space-time patterns we acquire techniques of glider detection (which could be useful if we design collision-based computing architectures), calculate input-entropy and pattern-density. The final chapters of the book are devoted to the automatic classification of the cell-state transitions rules, and the realisation of learning and forgetting within state-transition diagrams.

The book is a marvellous edition which will please every, even very particular, reader. It is written in a Wuensche-brand lively style, clear and explanatory, self-consistent and wonderfully illustrated. If we are even remotely interested in cellular automata, random Boolean networks, complex systems, or automata networks, we will certainly enjoy browsing through this book.

References:

Wuensche, A. and Lesser, M. (1992), The Global Dynamics of Cellular Automata: An Atlas of Basin of Attraction Fields of One-Dimensional Cellular Automata, Addison-Wesley, Reading, MA.
