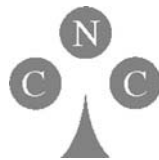


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Algorithmic Bioprocesses

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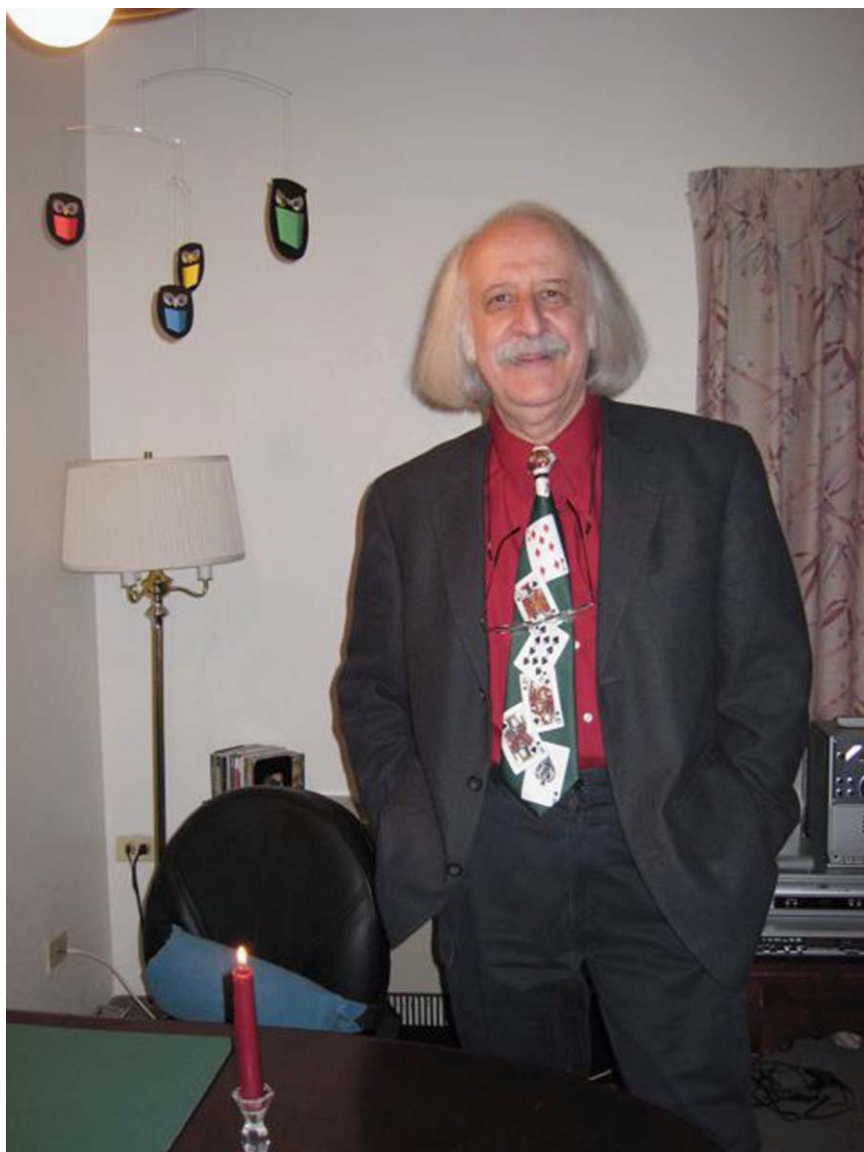
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This book is dedicated to Grzegorz Rozenberg



This image was created by DADARA

Preface

This Festschrift celebrates the 65th birthday of Grzegorz Rozenberg, one of the world leaders in research on theoretical computer science and natural computing. Grzegorz had—and still has—enormous influence on the development of both disciplines. He has published over 500 research papers, 6 books, and coedited about 90 books. His papers shaped research in a whole range of areas, including formal language and automata theory, the theory of concurrent systems, the theory of graph transformations, mathematical structures in computer science, and natural computing.

He is often referred to as a guru of natural computing, as he was promoting the vision of natural computing as a coherent scientific discipline already back in the 1970s.

He is especially fond of—and very successful in—interdisciplinary research. As a matter of fact, his education and research career is interdisciplinary in a quite symbolic way: His first degree was as an electronics engineer; he got his master's degree in computer science and his Ph.D. in mathematics, and for over 30 years he has worked closely with biologists on information processing in biological systems.

Grzegorz is well known for his work for the scientific community. Apparently, this has its roots at the beginning of his career in Poland, as he felt that scientists there were quite isolated and forgotten by their colleagues in the West. He promised himself that if he ever got out of Eastern Europe he would spend a considerable part of his life working for the community.

His current or past functions for the academic community include: president of the European Association for Theoretical Computer Science (EATCS); a cofounder and president of the International Society for Nanoscale Science, Computation, and Engineering (ISNSCE); chair of the steering committee of the DNA Computing Conference; chair of the steering committee of the International Conference on Application and Theory of Petri Nets; chair of the steering committee of the European Educational Forum; a cofounder and chair of the steering committee of the International Conference on Developments in Language Theory; and a cochair of the steering committee of the International Conference on Unconventional Computation.

He is on the editorial boards of many journals and book series. As a matter of fact, he was a cofounder of some well-known journals and book series, most notably the journal *Natural Computing*, the journal *Theoretical Computer Science C* (*Theory of Natural Computing*), the book series *Monographs and Texts in Theoretical Computer Science*, the book series *Natural Computing*, and the book series *Advances in*

Petri Nets. For over 20 years, he was the editor of the *Bulletin of the European Association for Theoretical Computer Science*, and is a coeditor of four handbooks—on formal languages, on graph grammars and computing by graph transformations, on membrane computing, and on natural computing.

He also made valuable contributions on the national scene in The Netherlands. For example, he was the founder and the first president of the Dutch Association for Theoretical Computer Science. Also, he initiated the Dutch Theory Day, which is today the main meeting forum for researchers working on theoretical computer science in The Netherlands.

His life in science is only one of his several lives. He is a professional magician—often performing at scientific conferences. Also, he spends a considerable part of his intellectual life studying the paintings of Hieronymus Bosch. [Apparently, he is writing a book on the art of Bosch.] But, most of all, he is a family man, and an admirer of the art of his son, DADARA. The phrase “family man” must be seen here in a broader context, as he calls his Ph.D. students and postdocs, and many of the scientists who come to work with him, “his children.” For more insight into Grzegorz’s life and personality, please see the tribute “Grzegorz Rozenberg: A Magical Scientist and Brother” by his close friend and collaborator Arto Salomaa in Part I of this book.

To celebrate the 65th birthday of Grzegorz, we organized in December 2007 a workshop on Algorithmic Bioprocesses at the Lorentz Center of Leiden University. The theme of the workshop is one of Grzegorz’s research areas, and it falls within the general field of natural computing which is certainly his favorite research field now. As a matter of fact, we wanted the workshop to reflect Grzegorz’s views of computer science and natural computing, which in a nutshell, can be explained as follows.

The spectacular progress in information and communications technology (ICT) is very much supported by the evolution of computer science which designs and develops the instruments needed for this progress: computers, computer networks, software methodologies, etc. Since ICT has a tremendous impact on our everyday life, so too does computer science. However, there is much more to computer science than ICT: It is the science of information processing, and, as such, it is a fundamental science for other scientific disciplines.

On the one hand, the only common denominator among the many, diverse research areas in computer science is that they require us to think about various aspects of information processing. Therefore, the frequently used term “informatics”—most commonly used in Europe—is much better than “computer science”; the latter stipulates that a specific instrument, namely the computer, is the main research topic of our discipline. On the other hand, one of the important developments of the last century for a number of other scientific disciplines is the adoption of information and information processing as central notions and frameworks of thought—biology and physics are prime examples here. For these scientific disciplines, informatics provides not only instruments but also a way of thinking. One of the grand challenges of informatics is to understand the world around us in terms of information processing.

Informatics (computer science) is now undergoing an important transformation which is stimulated to a great extent by all kinds of interactions with the natural sciences. It is adapting and extending its traditional notions of computation and computational techniques to account for computation taking place in nature around us.

Natural computing is concerned with computing taking place in nature as well as human-designed computing inspired by nature. Using the terminology of natural sciences, specifically biochemistry, one can say that natural computing is an important catalyst for the interactions between informatics and natural sciences, and hence an important catalyst for the ongoing, exciting development of informatics.

The main idea of the “Algorithmic Bioprocesses” workshop was to reflect the above point of view, and most importantly to reflect the power and excitement of interdisciplinary research, which forms the core of natural computing. We have chosen the name “Algorithmic Bioprocesses” because the workshop did not cover the whole spectrum of natural computing research, but rather it was mostly focused on the interactions between computer science on the one hand and biology, chemistry, and DNA-oriented nanoscience on the other.

The workshop turned out to be a great success due—among other reasons – to the fact that many world leaders of research in natural computing participated. It was also a very pleasant social event. Grzegorz was visibly happy with the workshop, obviously because of its high scientific level, but also because so many of the speakers were really his “children.”

The idea of a book based on the workshop had already occurred to us before the event, and participants suggested additional contributors to the book, especially scientists whose work is related to Grzegorz’s research interests. As a result, this book contains some contributions that were not presented at the workshop. We believe that the resulting book provides a valuable perspective on an important part of current research in natural computing.

The book is divided into parts which, with the exception of Part I, reflect various research areas related to algorithmic bioprocesses. Part I is a tribute to Grzegorz written by his very close friend and collaborator Arto Salomaa. Part II, “Sequence Discovery, Generation, and Analysis,” is concerned with many aspects of fundamental studies of biological systems. Part III, “Gene Assembly in Ciliates,” covers theoretical, computational, and experimental research on the process of gene assembly, including the hypothesis on the biological realization of this process. Part IV, “Nanoconstructions and Self-assembly,” discusses many aspects of nanoconstructions and self-assembly including theoretical and computational aspects as well as pragmatic considerations on implementations of physical chemistry processes. Part V, “Membrane Computing,” discusses the membrane computing model inspired by the compartmentalization of cells by biological membranes. It also surveys research on a more recent model of spiking neural P systems which is motivated by the behavior of spiking neural networks. Part VI, “Formal Models and Analysis,” surveys general computer science-inspired approaches to modeling and analysis of biological processes, such as the use of Petri nets, and the use of probabilistic model checking. It also presents models for specific biological phenomena such as recombination, the

eukaryotic heat shock response, the MAP kinase cascade, and the behavior of the calyx of Held synapse. Part VII, “Process Calculi and Automata,” deals with the relationship between automata and process calculi on the one hand and biochemistry on the other. It considers molecules as automata, biochemical implementation of automata, process calculi as a general framework for studying biological processes, and translations from process algebra models into differential equations—a more traditional framework used by biologists. Part VIII, “Biochemical Reactions,” considers problems of stochastic simulation and modeling in relation to dynamic description of biochemical reactions. Finally, Part IX, “Broader Perspective,” provides a more general setting for the book by adding a number of additional topics from natural computing. They include molecular evolution, regulation of gene expression, light-based computing, cellular automata, realistic modeling of biological systems, and evolutionary computing.

Thus, the book covers a wide spectrum of research topics from natural computing. Since it is a Festschrift, it is fitting to note here that Grzegorz made valuable research contributions to the research themes of all parts of this book.

We hope that this book will contribute to the further development of research in the very exciting and important area of natural computing, by providing valuable perspective and knowledge to researchers in natural computing, and by motivating and encouraging others to join this research field. Most of all, we hope that the book is really a worthy tribute to Grzegorz. We want to thank all the contributors for helping us to achieve these goals.

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Rehovot, Israel
Leiden, The Netherlands
Turku, Finland
Pasadena, USA

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David Harel
Joost N. Kok
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