

# COMPUTING WITH CELLS AND ATOMS

An introduction to quantum, DNA  
and membrane computing

Cristian S. Calude and Gheorghe Paun



# Computing With Cells And Atoms An Introduction To Quantum Dna And Membrane Computing

**Henning Bordihn, Martin Kutrib, Bianca  
Truthe**



## **Computing With Cells And Atoms An Introduction To Quantum Dna And Membrane Computing:**

**Computing with Cells and Atoms** Cris Calude, Gheorghe Paun, 2000-10-26 At the turning of the millennium a switch in computing technology is forecasted and looked for Two main directions of research both based on quite unconventional ideas are most promising quantum computing and molecular computing In the last few years both of these methods have been intensely investigated The present book is the first friendly presentation of basic ideas in these exciting areas The style is rigorous but without entering into excessive technicalities Equal attention is paid to the main practical results reported so far and the main theoretical developments The book is written for the educated layman and is self contained including all the necessary facts from mathematics computer science biology and quantum mechanics *Computing with Cells and Atoms* Cristian Calude, 2000

**Membrane Computing** Gheorghe Paun, 2003-02-25 This book constitutes the thoroughly refereed post proceedings of the International Workshop on Membrane Computing WMC CdeA 2002 held in Curtea de Arges Romania in August 2002 The 29 revised full papers presented were carefully selected during two rounds of reviewing and revision some were especially solicited for inclusion in the book after the workshop Most papers address membrane systems and membrane computing from the point of view of theoretical computer science some papers solve open problems and present new approaches and others provide mathematical and biological background All in all the book presents the state of the art in membrane computing

**DNA Computing** Natasa Jonoska, Nadriaan C. Seeman, 2002-05-28 This book constitutes the thoroughly refereed post proceedings of the 7th International Workshop on DNA Based Computers DNA7 held in Tampa Florida USA in June 2001 The 26 revised full papers presented together with 9 poster papers were carefully reviewed and selected from 44 submissions The papers are organized in topical sections on experimental tools theoretical tools probabilistic computational models computer simulation and sequence design algorithms experimental solutions nano tech devices biomimetic tools new computing models and splicing systems and membranes

**Theoretical and Experimental DNA Computation** Martyn Amos, 2005-10-17 DNA computation has emerged in the last ten years as an exciting new search eld at the intersection and some would say frontiers of computer science biology engineering and mathematics Although anticipated by Fe man as long ago as the 1950s the notion of performing computations at a molecular level was only realized in 1994 with Adleman s seminal work on computing with DNA Since then the eld has blossomed rapidly with signi cant theoretical and experimental results being reported regularly Several books have described various aspects of DNA computation but this is to the author s best knowledge the rst to bring together descriptions of both theoretical and experimental results The target audience is intentionally broad including students as well as experienced researchers We expect that users of the book will have some background in either computer science mathematics engineering or the life sciences The intention is that this book be used as a tutorial guide for newcomers to the eld as well as a reference text for people already working in this fascinating area To this end we include two self contained tutorial chapters 1 and 2 which

convey only those aspects of computer science and biology that are required to understand the subsequent material     The Zen of Exotic Computing Peter M. Kogge, 2022-12-07 The Turing von Neumann model of computing is dominant today but is by no means the only one This textbook explores an important subset of alternatives including those such as quantum and neuromorphic which receive daily news attention The models are organized into distinct groups After a review of the Turing von Neumann model to set the stage the author discusses those that have their roots in the Turing von Neumann model but perform potentially large numbers of computations in parallel models that do away with the preplanned nature of the classical model and compute from just a statement of the problem others that are simply mathematically different such as probabilistic and reversible computation models based on physical phenomena such as neurons and finally those that leverage unique physical phenomena directly such as quantum optical and DNA based computing Suggested readings provide a jumping off point for deeper learning A supplemental website contains chapters that did not make it into the book as well as exercises projects and additional resources that will be useful for more in depth investigations The Zen of Exotic Computing is intended for computer science students interested in understanding alternative models of computing It will also be of interest to researchers and practitioners interested in emerging technology such as quantum computing machine learning and AI     *Distributed Computing and Internet Technology* Raja Natarajan, Adegboyega Ojo, 2011-02-02 This book constitutes the proceedings of the 7th International Conference on Distributed Computing and Internet Technology ICDIT 2011 held in Bhubaneswar India in February 2011 The 18 papers presented in this volume were carefully reviewed and selected from 138 submissions In addition the book contains the full versions of 6 invited talks The papers are grouped in topical sections on distributed computing sensor networks internet technologies and applications security and bio inspired computing     **Systems Self-Assembly** , 2011-09-22 Systems Self Assembly is the only book to showcase state of the art self assembly systems that arise from the computational biological chemical physical and engineering disciplines Written by world experts in each area it provides a coherent integrated view of both book practice examples and new trends with a clearly presented computational flavor The unifying thread throughout the text is the computational nature of self assembling systems This book consists of 13 chapters dealing with a variety of topics such as the patterns of self organised nanoparticle assemblies biomimetic design of dynamic self assembling systems computing by self assembly involving DNA molecules polyominoes and cells evolutionary design of a model of self assembling chemical structures self assembly as an engineering concept across size scales and probabilistic analysis of self assembled molecular networks Other chapters focus on the programming language of dynamic self assembly self assembled computer architectures simulation of self assembly processes using abstract reduction systems computer aided search for optimal self assembly systems theoretical aspects of programmable self assembly emergent cooperativity in large scale patterns and automated self assembling programming Systems Self Assembly is an ideal reference for scientists researchers and post graduate students practitioners in industry

engineering and science and managers decision makers and policy makers The only book to showcases state of the art self assembly systems that arise from the computational biological chemical physical and engineering disciplines Coherent integrated view of both book practice examples and new trends with a clearly presented computational flavor Written by world experts in each area *Machines, Computations, and Universality* Jerome Durand-Lose, Benedek Nagy, 2015-08-29

This book constitutes the refereed proceedings of the 7th International Conference on Machines Computations and Universality MCU 2015 held in Famagusta North Cyprus in September 2015 The 10 revised full papers presented together with 4 invited talks were carefully reviewed and selected from 23 submissions MCU explores computation in the setting of various discrete models Turing machines register machines cellular automata tile assembly systems rewriting systems molecular computing models neural models etc and analog and hybrid models BSS machines infinite time cellular automata real machines quantum computing etc **Computation, Cooperation, and Life** Jozef Kelemen, Alica

Kelemenová, 2011-06-21 Gheorghe P un has played an important role within a wide range of disciplines from the foundations of traditional computation theory and formal language theory to research gaining its inspiration from living nature He has significantly contributed to the development of these diverse fields initiating and pioneering some of them with remarkable imaginativeness and enthusiasm Gheorghe P un s research focusses on systems inspired by structures and processes found in living systems with the field of membrane computing or P systems being the most important of his initiatives This Festschrift volume published to honor Gheorghe P un on the occasion of his 60th birthday includes 16 contributions by his students and collaborators The research presented aims to gain a better understanding of what computation is to find better models of computation and to look for new computing devices inspired by the structure and or functioning of natural or societal systems The papers are preceded by an introduction by Solomon Marcus Gheorghe P un s lifelong teacher and mentor and are organized in topical sections on general computing grammar systems membrane systems and inspirations from natural computing *Multi-Objective Optimization in Computational Intelligence: Theory and Practice* Thu Bui, Lam, Alam,

Sameer, 2008-05-31 Multi objective optimization MO is a fast developing field in computational intelligence research Giving decision makers more options to choose from using some post analysis preference information there are a number of competitive MO techniques with an increasingly large number of MO real world applications Multi Objective Optimization in Computational Intelligence Theory and Practice explores the theoretical as well as empirical performance of MOs on a wide range of optimization issues including combinatorial real valued dynamic and noisy problems This book provides scholars academics and practitioners with a fundamental comprehensive collection of research on multi objective optimization techniques applications and practices Unconventional Models of Computation Cristian Calude, Michael J. Dinneen, F. Peper, 2003-06-30 This book constitutes the refereed proceedings of the Third International Conference on Unconventional Models of Computation UMC 2002 held in Kobe Japan in October 2002 The 18 revised full papers presented together with

eight invited full papers were carefully reviewed and selected from 36 submissions All major areas of unconventional computing models are covered especially quantum computing DNA computing membrane computing cellular computing and possibilities to break Turing's barrier The authors address theoretical aspects practical implementations as well as philosophical reflections

**Quantum Computer Science** Marco Lanzagorta, Jeffrey Uhlmann, 2022-05-31 In this text we present a technical overview of the emerging field of quantum computation along with new research results by the authors What distinguishes our presentation from that of others is our focus on the relationship between quantum computation and computer science Specifically our emphasis is on the computational model of quantum computing rather than on the engineering issues associated with its physical implementation We adopt this approach for the same reason that a book on computer programming doesn't cover the theory and physical realization of semiconductors Another distinguishing feature of this text is our detailed discussion of the circuit complexity of quantum algorithms To the extent possible we have presented the material in a form that is accessible to the computer scientist but in many cases we retain the conventional physics notation so that the reader will also be able to consult the relevant quantum computing literature Although we expect the reader to have a solid understanding of linear algebra we do not assume a background in physics This text is based on lectures given as short courses and invited presentations around the world and it has been used as the primary text for a graduate course at George Mason University In all these cases our challenge has been the same how to present to a general audience a concise introduction to the algorithmic structure and applications of quantum computing on an extremely short period of time The feedback from these courses and presentations has greatly aided in making our exposition of challenging concepts more accessible to a general audience

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*Emerging and Future Computing Paradigms and Their Impact on the Research, Training, and Design Environments of the Aerospace Workforce*, 2003

Irreducibility and Computational Equivalence

Hector Zenil, 2012-12-25 It is clear that computation is playing an increasingly prominent role in the development of mathematics as well as in the natural and social sciences The work of Stephen Wolfram over the last several decades has been a salient part in this phenomenon helping founding the field of Complex Systems with many of his constructs and ideas incorporated in his book *A New Kind of Science* ANKS becoming part of the scientific discourse and general academic knowledge from the now established Elementary Cellular Automata to the unconventional concept of mining the Computational Universe from today's widespread Wolfram's Behavioural Classification to his principles of Irreducibility and Computational Equivalence This volume with a Foreword by Gregory Chaitin and an Afterword by Cris Calude covers these and other topics related to or motivated by Wolfram's seminal ideas reporting on research undertaken in the decade

following the publication of Wolfram's NKS book. Featuring 39 authors, its 23 contributions are organized into seven parts: Mechanisms in Programs, Nature Systems Based on Numbers, Simple Programs, Social and Biological Systems, Technology, Fundamental Physics, The Behavior of Systems, the Notion of Computation, Irreducibility, Computational Equivalence, Reflections and Philosophical Implications. Computational Intelligence, Cyber Security and Computational Models. Recent Trends in Computational Models, Intelligent and Secure Systems Indhumathi Raman, Poonthalir Ganesan, Venkatasamy Sureshkumar, Latha Ranganathan, 2022-10-01. This book constitutes the proceedings of the 5th International Conference ICC3 2021 held in Coimbatore, India, during December 16-18, 2021. The 14 full papers included in this book were carefully reviewed and selected from 84 submissions. They were organized in topical sections as follows: computational intelligence, cyber security, and computational models. **Recent Developments in Biologically Inspired Computing** Leandro N. De Castro, Fernando J. Von Zuben, 2005-01-01. Recent Developments in Biologically Inspired Computing is necessary reading for undergraduate and graduate students and researchers interested in knowing the most recent advances in problem-solving techniques inspired by nature. This book covers the most relevant areas in computational intelligence, including evolutionary algorithms, artificial neural networks, artificial immune systems, and swarm systems. It also brings together novel and philosophical trends in the exciting fields of artificial life and robotics. This book has the advantage of covering a large number of computational approaches, presenting the state of the art before entering into the details of specific extensions and new developments. Pseudocodes, flow charts, and examples of applications are provided so as to help newcomers and mature researchers to get the point of the new approaches presented. Molecular Computing Weng-Long Chang, Athanasios V. Vasilakos, 2014-07-08. This textbook introduces a concise approach to the design of molecular algorithms for students or researchers who are interested in dealing with complex problems. Through numerous examples and exercises, you will understand the main difference of molecular circuits and traditional digital circuits to manipulate the same problem, and you will also learn how to design a molecular algorithm of solving any problem from start to finish. The book starts with an introduction to computational aspects of digital computers and molecular computing, data representation of molecular computing, molecular operations of molecular computing, and number representation of molecular computing and provides many molecular algorithms to construct the parity generator and the parity checker of error detection codes on digital communication, to encode integers of different formats, single precision and double precision of floating-point numbers, to implement addition and subtraction of unsigned integers, to construct logic operations including NOT, OR, AND, NOR, NAND, Exclusive OR, XOR, and Exclusive NOR, XNOR, to implement comparators, shifters, increase, decrease, and to complete two specific operations that are to find the maximum number of 1s and to find the minimum number of 1s. The book is also a useful reference source to people new to the field of molecular computing. **Entangled Systems** Jürgen Audretsch, 2008-09-26. An introductory textbook for advanced students of physics, chemistry, and computer science, covering an area of physics that

has lately witnessed rapid expansion The topics treated here include quantum information quantum communication quantum computing teleportation and hidden parameters thus imparting not only a well founded understanding of quantum theory as such but also a solid basis of knowledge from which readers can follow the rapid development of the topic or delve deeper into a more specialized branch of research Commented recommendations for further reading as well as end of chapter problems help the reader to quickly access the theoretical basics of future key technologies     *Languages Alive* Henning Bordihn, Martin Kutrib, Bianca Truthe, 2012-07-18 This festschrift volume published in honor of Jürgen Dassow on the occasion of his 65th birthday contains 19 contributions by leading researchers colleagues and friends Covering topics on picture languages cooperating distributed systems of automata quantum automata grammar systems online computation word equations biologically motivated formal systems controlled derivations descriptional complexity as well as classical topics of automata and language theory the articles presented span the range of the scientific work of Jürgen Dassow



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