

# **Simulating Complex Systems By Cellular Automata Understanding Complex Systems**

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Complex Systems IVSimulation of Complex Systems in  
GISUnifying Themes in Complex SystemsThe  
Dynamics of Complex Urban SystemsModeling and  
Simulation of Complex SystemsComplex Systems,  
Sustainability and InnovationModeling Chemical  
Systems Using Cellular AutomataROBOT 2017: Third  
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Models Computational Science - ICCS 2009 Single-Cell-  
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## **Agent-Based Approaches in Economic and Social Complex Systems IV**

This fascinating, colourful book offers in-depth insights and first-hand working experiences in the production of art works, using simple computational models with rich morphological behaviour, at the edge of mathematics, computer science, physics and biology. It organically combines ground breaking scientific discoveries in the theory of computation and complex systems with artistic representations of the research results. In this appealing book mathematicians, computer scientists, physicists, and engineers brought together marvelous and esoteric patterns generated by cellular automata, which are arrays of simple machines with complex behavior. Configurations produced by cellular automata uncover mechanics of dynamic patterns formation, their

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propagation and interaction in natural systems: heart pacemaker, bacterial membrane proteins, chemical reactors, water permeation in soil, compressed gas, cell division, population dynamics, reaction-diffusion media and self-organisation. The book inspires artists to take on cellular automata as a tool of creativity and it persuades scientists to convert their research results into the works of art. The book is lavishly illustrated with visually attractive examples, presented in a lively and easily accessible manner.

### **Simulation of Complex Systems in GIS**

Welcome to the proceedings of the Seventh International Conference of the UK Systems Society being held at York University, United Kingdom from July 7th to 10th, 2002. It is a pleasure to be able to share with you this collection of papers that have been contributed by systems thinkers from around the world. As with previous UKSS conferences, the aim of this conference is to encourage debate and promote development of pertinent issues in systems theory and practice. In current times where the focus has moved from 'information' to 'knowledge' and where 'knowledge management', of everyday speak, it seemed fitting to 'knowledge assets' and so on, have become part offer a conference title of 'Systems Theory and Practice in the Knowledge Age'. In keeping with another tradition of previous conferences, the UKSS Conference 2002 Committee decided to compile a collection of delegates' papers before the event as a platform from which to launch discussions in York. Ideas presented in the following

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papers will, undoubtedly, be developed during the dialogue generated at the conference and new papers will emerge. In his abstract for his plenary at this conference, Professor Peter Checkland throws down the gauntlet to systems thinking and its relevance in the knowledge age with the following statement: "30 Years In The Systems Movement: Disappointments I Have Known and Hopes/or the Future Springing from a lunchtime conversation at an American University, the Systems Movement is now nearly 50 years old.

## **Unifying Themes in Complex Systems**

Soft computing embraces various methodologies for the development of intelligent systems that have been successfully applied to a large number of real-world problems. *Soft Computing in Industry* contains a collection of papers that were presented at the 6th On-line World Conference on Soft Computing in Industrial Applications that was held in September 2001. It provides a comprehensive overview of recent theoretical developments in soft computing as well as of successful industrial applications. It is divided into seven parts covering material on: keynote papers on various subjects ranging from computing with autopoietic systems to the effects of the Internet on education; intelligent control; classification, clustering and optimization; image and signal processing; agents, multimedia and Internet; theoretical advances; prediction, design and diagnosis. The book is aimed at researchers and professional engineers who develop and apply intelligent systems in computer engineering.

## **The Dynamics of Complex Urban Systems**

This book aims to develop models and modeling techniques that are useful when applied to all complex systems. It adopts both analytic tools and computer simulation. The book is intended for students and researchers with a variety of backgrounds.

### **Modeling and Simulation of Complex Systems**

“There is something fascinating about science. One gets such wholesale returns of conjecture out of such a trifling investment of fact.” Mark Twain, *Life on the Mississippi*

The challenges in succeeding with computational science are numerous and deeply affect all disciplines. NSF’s 2006 Blue Ribbon Panel of Simulation-Based Engineering Science (SBES) states ‘researchers and educators [agree]: computational and simulation engineering sciences are fundamental to the security and welfare of the United States. . . We must overcome difficulties inherent in multiscale modeling, the development of next-generation algorithms, and the design. . . of dynamic data-driven application systems. . . We must determine better ways to integrate data-intensive computing, visualization, and simulation. . . importantly, we must overhaul our educational system to foster the interdisciplinary study. . . The payoff for meeting these challenges are profound.’

The International Conference on Computational Science 2009 (ICCS 2009) explored how computational sciences are not only advancing

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the traditional hard science disciplines, but also stretching beyond, with applications in the arts, humanities, media and all aspects of research. This interdisciplinary conference drew academic and industry leaders from a variety of fields, including physics, astronomy, mathematics, music, digital media, biology and engineering. The conference also hosted computer and computational scientists who are designing and building the infrastructure necessary for next-generation computing. Discussions focused on innovative ways to collaborate and how computational science is changing the future of research. ICCS 2009: 'Compute. Discover. Innovate.' was hosted by the Center for Computation and Technology at Louisiana State University in Baton Rouge.

## **Complex Systems, Sustainability and Innovation**

This book constitutes the refereed proceedings of the 7th International Conference on Cellular Automata for Research and Industry, ACRI 2006. The book presents 53 revised full papers and 19 revised poster papers together with 6 invited lectures. Topical sections include CA theory and implementation, computational theory, population dynamics, physical modeling, urban, environmental and social modeling, traffic and boolean networks, multi-agents and robotics, as well as crowds and cellular automata, and more.

## **Modeling Chemical Systems Using**

## **Cellular Automata**

Complexity is emerging as a post-Newtonian paradigm for approaching a large body of phenomena of concern at the crossroads of physical, engineering, environmental, life and human sciences from a unifying point of view. This book outlines the foundations of modern complexity research as it arose from the cross-fertilization of ideas and tools from nonlinear science, statistical physics and numerical simulation. It is shown how these developments lead to an understanding, both qualitative and quantitative, of the complex systems encountered in nature and in everyday experience and, conversely, how natural complexity acts as a source of inspiration for progress at the fundamental level.

## **ROBOT 2017: Third Iberian Robotics Conference**

This book explores the process of modeling complex systems in the widest sense of that term, drawing on examples from such diverse fields as ecology, epidemiology, sociology, seismology, as well as economics. It also provides the mathematical tools for studying the dynamics of these systems. Boccara takes a carefully inductive approach in defining what it means for a system to be "complex" (and at the same time addresses the equally elusive concept of emergent properties). This is the first text on the subject to draw comprehensive conclusions from such a wide range of analogous phenomena.

## **Designing Beauty: The Art of Cellular Automata**

High Performance Computing Systems and Applications contains the fully refereed papers from the 13th Annual Symposium on High Performance Computing, held in Kingston, Canada, in June 1999. This book presents the latest research in HPC architectures, distributed and shared memory performance, algorithms and solvers, with special sessions on atmospheric science, computational chemistry and physics. High Performance Computing Systems and Applications is suitable as a secondary text for graduate level courses, and as a reference for researchers and practitioners in industry.

## **Towards the Integration of Complex Systems Theory, Geographic Information Science, and Network Science for Modelling Geospatial Phenomena**

Aimed at postgraduate students in a variety of biology-related disciplines, this volume presents a collection of mathematical and computational single-cell-based models and their application. The main sections cover four general model groupings: hybrid cellular automata, cellular potts, lattice-free cells, and viscoelastic cells. Each section is introduced by a discussion of the applicability of the particular modelling approach and its advantages and disadvantages, which will make the book suitable for students starting research in mathematical biology as well as scientists modelling multicellular processes.

## **Unifying Themes in Complex Systems IX**

These volumes of "Advances in Intelligent Systems and Computing" highlight papers presented at the "Third Iberian Robotics Conference (ROBOT 2017)". Held from 22 to 24 November 2017 in Seville, Spain, the conference is a part of a series of conferences co-organized by SEIDROB (Spanish Society for Research and Development in Robotics) and SPR (Portuguese Society for Robotics). The conference is focused on Robotics scientific and technological activities in the Iberian Peninsula, although open to research and delegates from other countries. Thus, it has more than 500 authors from 21 countries. The volumes present scientific advances but also robotic industrial applications, looking to promote new collaborations between industry and academia.

### **E-Cell System**

The boundaries between simple and complicated, and complicated and complex system designations are fuzzy and debatable, even using quantitative measures of complexity. However, if you are a biomedical engineer, a biologist, physiologist, economist, politician, stock market speculator, or politician, you have encountered complex systems. Furthermore, your success depends on your ability to successfully interact with and manage a variety of complex systems. In order not to be blindsided by unexpected results, we need a systematic, comprehensive way of analyzing, modeling, and simulating complex systems to predict non-

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anticipated outcomes. In its engaging first chapters, the book introduces complex systems, Campbell's Law, and the Law of Unintended Consequences, and mathematics necessary for conversations in complex systems. Subsequent chapters illustrate concepts via commonly studied biological mechanisms. The final chapters focus on higher-level complexity problems, and introduce complexity in economic systems. Designed as a reference for biologists and biological engineers, *Introduction to Complexity and Complex Systems* lends itself to use in a classroom course to introduce advanced students studying biomedical engineering, biophysics, or physiology to complex systems. Engaging and illustrative, this book aids scientists and decision makers in managing biological complexity and complex systems.

### **Systems Theory and Practice in the Knowledge Age**

A comprehensive text that reviews the methods and technologies that explore emergent behavior in complex systems engineering in multidisciplinary fields. In *Emergent Behavior in Complex Systems Engineering*, the authors present the theoretical considerations and the tools required to enable the study of emergent behaviors in manmade systems. Information Technology is key to today's modern world. Scientific theories introduced in the last five decades can now be realized with the latest computational infrastructure. Modeling and simulation, along with Big Data technologies are at the forefront of such exploration and investigation.

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The text offers a number of simulation-based methods, technologies, and approaches that are designed to encourage the reader to incorporate simulation technologies to further their understanding of emergent behavior in complex systems. The authors present a resource for those designing, developing, managing, operating, and maintaining systems, including system of systems. The guide is designed to help better detect, analyse, understand, and manage the emergent behaviour inherent in complex systems engineering in order to reap the benefits of innovations and avoid the dangers of unforeseen consequences. This vital resource:

- Presents coverage of a wide range of simulation technologies
- Explores the subject of emergence through the lens of Modeling and Simulation (M&S)
- Offers contributions from authors at the forefront of various related disciplines such as philosophy, science, engineering, sociology, and economics
- Contains information on the next generation of complex systems engineering

Written for researchers, lecturers, and students, *Emergent Behavior in Complex Systems Engineering* provides an overview of the current discussions on complexity and emergence, and shows how systems engineering methods in general and simulation methods in particular can help in gaining new insights in complex systems engineering.

## **Advanced Geo-Simulation Models**

Deeply rooted in fundamental research in Mathematics and Computer Science, Cellular

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Automata (CA) are recognized as an intuitive modeling paradigm for Complex Systems. Already very basic CA, with extremely simple micro dynamics such as the Game of Life, show an almost endless display of complex emergent behavior. Conversely, CA can also be designed to produce a desired emergent behavior, using either theoretical methodologies or evolutionary techniques.

Meanwhile, beyond the original realm of applications - Physics, Computer Science, and Mathematics - CA have also become work horses in very different disciplines such as epidemiology, immunology, sociology, and finance. In this context of fast and impressive progress, spurred further by the enormous attraction these topics have on students, this book emerges as a welcome overview of the field for its practitioners, as well as a good starting point for detailed study on the graduate and post-graduate level. The book contains three parts, two major parts on theory and applications, and a smaller part on software. The theory part contains fundamental chapters on how to design and/or apply CA for many different areas. In the applications part a number of representative examples of really using CA in a broad range of disciplines is provided - this part will give the reader a good idea of the real strength of this kind of modeling as well as the incentive to apply CA in their own field of study. Finally, we included a smaller section on software, to highlight the important work that has been done to create high quality problem solving environments that allow to quickly and relatively easily implement a CA model and run simulations, both on the desktop and if needed, on High Performance Computing infrastructures.

## **Large-Scale Computing Techniques for Complex System Simulations**

This proceedings volume contains a selection of papers presented at the Fourth International Conference on High Performance Scientific Computing held at the Hanoi Institute of Mathematics, Vietnamese Academy of Science and Technology (VAST), March 2-6, 2009. The conference was organized by the Hanoi Institute of Mathematics, the Interdisciplinary Center for Scientific Computing (IWR), Heidelberg, and its Heidelberg Graduate School of Mathematical and Computational Methods for the Sciences, and Ho Chi Minh City University of Technology. The contributions cover the broad interdisciplinary spectrum of scientific computing and present recent advances in theory, development of methods, and applications in practice. Subjects covered are mathematical modelling, numerical simulation, methods for optimization and control, parallel computing, software development, applications of scientific computing in physics, mechanics, biology and medicine, engineering, hydrology problems, transport, communication networks, production scheduling, industrial and commercial problems.

### **Soft Computing and Industry**

This book contains the courses given at the Fifth School on Complex Systems held at Santiago, Chile, from 9th .to 13th December 1996. At this school met researchers working on areas related with recent

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trends in Complex Systems, which include dynamical systems, cellular automata, symbolic dynamics, spatial systems, statistical physics and thermodynamics. Scientists working in these subjects come from several areas: pure and applied mathematics, physics, biology, computer science and electrical engineering. Each contribution is devoted to one of the above subjects. In most cases they are structured as surveys, presenting at the same time an original point of view about the topic and showing mostly new results. The paper of Bruno Durand presents the state of the art on the relationships between the notions of surjectivity, injectivity and reversibility in cellular automata when finite, infinite or periodic configurations are considered, also he discusses decidability problems related with the classification of cellular automata as well as global properties mentioned above. The paper of Eric Goles and Martin Matamala gives a uniform presentation of simulations of Turing machines by cellular automata. The main ingredient is the encoding function which must be fixed for all Turing machine. In this context known results are revised and new results are presented.

## **Unifying Themes in Complex Systems IV**

This volume constitutes the proceedings of the 18th Asia Simulation Conference, AsiaSim 2018, held in Kyoto, Japan, in August 2018. The 45 revised full papers presented in this volume were carefully reviewed and selected from 90 submissions. The papers are organized in topical sections on modeling

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and simulation technology; soft computing and machine learning; high performance computing and cloud computing; simulation technology for industry; simulation technology for intelligent society; simulation of instrumentation and control application; computational mathematics and computational science; flow simulation; visualization and computer vision to support simulation.

## **Modeling Cities and Regions as Complex Systems**

This book constitutes the proceedings of the 11th International Conference on Parallel Computing Technologies, PaCT 2011, held in Kazan, Russia on September 19-23, 2011. The 44 full papers presented together with 2 invited papers were carefully reviewed and selected from 68 submissions. The papers are organized in topical sections on models and languages, cellular automata, parallel programming tools and support, and applications.

## **Dynamics Of Complex Systems**

The theory and practice of modeling cities and regions as complex, self-organizing systems, presenting widely used cellular automata-based models, theoretical discussions, and applications.

## **Modeling, Simulation and Optimization of Complex Processes**

The book on complex systems, sustainability, and

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innovation explores a broad set of ideas and presents some of the state-of-the-art research in this field concisely in six chapters. In a complex system, it is difficult to know exactly how the individual components contribute to an observed behavior and the extent of each component's contributions. It is the interactions of the individual components that determine the emergent functionalities. This makes it difficult to understand and predict the behavior of complex systems and hence the effects of any innovations in this field. This necessitates for the emergence of a new age of innovations with the main focus on user orientation and sustainability. This book explores some of the complex systems and their dependence on the environment to provide a long-term perspective, aiding innovations and supporting a sustainable society. The intended audience of this book will mainly consist of researchers, research students, and practitioners in the field of complex systems and sustainability.

### **Simulating Complex Systems by Cellular Automata**

The only book to present the synergy between modeling and simulation, systems engineering, and agent technologies expands the notion of agent-based simulation to also deal with agent simulation and agent-supported simulation. Accessible to both practitioners and managers, it systematically addresses designing and building agent systems from a systems engineering perspective.

## **Nonlinear Physics for Beginners**

When originally published in 2005 this title included a CD ROM. In its POD version that is no longer a part of the selling unit.

## **Social-Behavioral Modeling for Complex Systems**

Robert Siegfried presents a framework for efficient agent-based modeling and simulation of complex systems. He compares different approaches for describing structure and dynamics of agent-based models in detail. Based on this evaluation the author introduces the “General Reference Model for Agent-based Modeling and Simulation” (GRAMS). Furthermore he presents parallel and distributed simulation approaches for execution of agent-based models -from small scale to very large scale. The author shows how agent-based models may be executed by different simulation engines that utilize underlying hardware resources in an optimized fashion.

## **AsiaSim 2013**

The interdisciplinary field of molecular systems biology aims to understand the behavior and mechanisms of biological processes composed of individual molecular components. As we gain more qualitative and quantitative information of complex intracellular processes, biochemical modeling and simulation become indispensable not only to uncover

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the molecular mechanisms of the processes, but to perform useful predictions. To this end, the E-Cell System, a multi-algorithm, multi-timescale object-oriented simulation platform, can be used to construct predictive virtual biological systems. Gene regulatory and biochemical networks that constitute a sub- or a whole cellular system can be constructed using the E-Cell System to perform qualitative and quantitative analyses. The purpose of E-Cell System: Basic Concepts and Applications is to provide a comprehensive guide for the E-Cell System version 3 in terms of the software features and its usage. While the publicly available E-Cell Simulation Environment version 3 User's Manual provides the technical details of model building and scripting, it does not describe some of the underlying concepts of the E-Cell System. The first part of the book addresses this issue by providing the basic concepts of modeling and simulation with the E-Cell System.

## **Parallel Computing Technologies**

This book constitutes the refereed proceedings of the 13th International Conference on Systems Simulation, Asia Simulation 2013, held in Singapore, in November 2013. The 45 revised full papers presented together with 18 short papers were carefully reviewed and selected from numerous submissions. The papers address issues such as agent based simulation, scheduling algorithms, simulation methods and tools, simulation and visualization, modeling methodology, simulation in science and engineering, high performance computing and simulation and parallel

## **Agent-Directed Simulation and Systems Engineering**

This volume describes frontiers in social-behavioral modeling for contexts as diverse as national security, health, and on-line social gaming. Recent scientific and technological advances have created exciting opportunities for such improvements. However, the book also identifies crucial scientific, ethical, and cultural challenges to be met if social-behavioral modeling is to achieve its potential. Doing so will require new methods, data sources, and technology. The volume discusses these, including those needed to achieve and maintain high standards of ethics and privacy. The result should be a new generation of modeling that will advance science and, separately, aid decision-making on major social and security-related subjects despite the myriad uncertainties and complexities of social phenomena. Intended to be relatively comprehensive in scope, the volume balances theory-driven, data-driven, and hybrid approaches. The latter may be rapidly iterative, as when artificial-intelligence methods are coupled with theory-driven insights to build models that are sound, comprehensible and usable in new situations. With the intent of being a milestone document that sketches a research agenda for the next decade, the volume draws on the wisdom, ideas and suggestions of many noted researchers who draw in turn from anthropology, communications, complexity science, computer science, defense planning, economics,

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engineering, health systems, medicine, neuroscience, physics, political science, psychology, public policy and sociology. In brief, the volume discusses: Cutting-edge challenges and opportunities in modeling for social and behavioral science Special requirements for achieving high standards of privacy and ethics New approaches for developing theory while exploiting both empirical and computational data Issues of reproducibility, communication, explanation, and validation Special requirements for models intended to inform decision making about complex social systems

### **Modelling and Simulation of Electrical Energy Systems Through a Complex Systems Approach Using Agent-Based Models**

Almost all real systems are nonlinear. For a nonlinear system the superposition principle breaks down: The system's response is not proportional to the stimulus it receives; the whole is more than the sum of its parts. The three parts of this book contains the basics of nonlinear science, with applications in physics. Part I contains an overview of fractals, chaos, solitons, pattern formation, cellular automata and complex systems. In Part II, 14 reviews and essays by pioneers, as well as 10 research articles are reprinted. Part III collects 17 students projects, with computer algorithms for simulation models included. The book can be used for self-study, as a textbook for a one-semester course, or as supplement to other courses in linear or nonlinear systems. The reader should have

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some knowledge in introductory college physics. No mathematics beyond calculus and no computer literacy are assumed. Request Inspection Copy

### **Computational Science - ICCS 2009**

This book contains the contributions presented at the international workshop "The Dynamics of Complex Urban Systems: an interdisciplinary approach" held in Ascona, Switzerland in November 2004. Experts from several disciplines outline a conceptual framework for modeling and forecasting the dynamics of both growth-limited cities and megacities. Coverage reflects the various interdependencies between structural and social development.

### **Single-Cell-Based Models in Biology and Medicine**

This book provides a comprehensive view of geographical modeling. It first establishes the foundations of geographical modeling, covering such concepts as structure, organization, system, topologies, as well as the concept of time. Next, it tackles the use of computer tools for dynamic model building and presents several models applied to various themes, such as urban growth, natural risks, as well as political themes. Finally, a general model of the geographic agents system (GAS), which can be used as a basis for the construction of a model-building platform for dynamic spatial models is presented.

## **Cellular Automata and Complex Systems**

In the last decade there has been a phenomenal growth in interest in crime pattern analysis. Geographic information systems are now widely used in urban police agencies throughout industrial nations. With this, scholarly interest in understanding crime patterns has grown considerably. Artificial Crime Analysis Systems: Using Computer Simulations and Geographic Information Systems discusses leading research on the use of computer simulation of crime patterns to reveal hidden processes of urban crimes, taking an interdisciplinary approach by combining criminology, computer simulation, and geographic information systems into one comprehensive resource.

## **High Performance Computing Systems and Applications**

The chapters of this book are the selected papers from those presented at the Third International Workshop on Agent-Based Approaches in Economic and Social Complex Systems held in Tokyo, Japan in 2005. Articles cover methodological issues, computational model/software, combination with gaming simulation, and real-world applications to economic, management/organizational and social issues.

## **Emergent Behavior in Complex Systems Engineering**

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"Geosimulation has recently emerged at the intersection of Geographic Information Science, Complex Systems Theory and Computer Science. Geosimulation aims at understanding the dynamics of complex human-driven spatial systems through the use of spatially ex"

## **Introduction to Complexity and Complex Systems**

Viewing urban dynamics in the context of complexity theory; models and examples in scales from the local to the regional.

## **Modeling Complex Systems**

In June of 2002, over 500 professors, students and researchers met in Boston, Massachusetts for the Fourth International Conference on Complex Systems. The attendees represented a remarkably diverse collection of fields: biology, ecology, physics, engineering, computer science, economics, psychology and sociology. The goal of the conference was to encourage cross-fertilization between the many disciplines represented and to deepen understanding of the properties common to all complex systems. This volume contains 43 papers selected from the more than 200 presented at the conference. Topics include: cellular automata, neurology, evolution, computer science, network dynamics, and urban planning. About NECSI: For over 10 years, The New England Complex Systems Institute (NECSI) has been instrumental in the

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development of complex systems science and its applications. NECSI conducts research, education, knowledge dissemination, and community development around the world for the promotion of the study of complex systems and its application for the betterment of society. NECSI hosts the International Conference on Complex Systems and publishes the NECSI Book Series in conjunction with Springer Publishers. ALI MINAI is an Affiliate of the New England Complex Systems Institute and an Associate Professor in the Department of Electrical and Computer Engineering and Computer Science at the University of Cincinnati. YANEER BAR-YAM is President and founder of the New England Complex Systems Institute. He is the author of Dynamics of Complex Systems and Making Things Work: Solving Complex Problems in a Complex World.

## **Foundations of Complex Systems**

Unifying Themes in Complex Systems is a well-established series of carefully edited conference proceedings that serve to document and archive the progress made regarding cross-fertilization in this field. The International Conference on Complex Systems (ICCS) creates a unique atmosphere for scientists from all fields, engineers, physicians, executives, and a host of other professionals, allowing them to explore common themes and applications of complex systems science. With this new volume, Unifying Themes in Complex Systems continues to establish common ground between the wide-ranging domains of complex systems science.

## **Cellular Automata**

In recent years, scientists have applied the principles of complex systems science to increasingly diverse fields. The results have been nothing short of remarkable. The Third International Conference on Complex Systems attracted over 400 researchers from around the world. The conference aimed to encourage cross-fertilization between the many disciplines represented and to deepen our understanding of the properties common to all complex systems.

## **Artificial Crime Analysis Systems: Using Computer Simulations and Geographic Information Systems**

## **Methods and Applications for Modeling and Simulation of Complex Systems**

A complex systems approach conceptualizes spatial systems from the bottom-up to better understand how local spatial interactions generate emergent system-level behavior and spatial patterns at large spatial extents. This approach can be applied to examine ecological, urban, and social systems within contexts of geographic space and time. Geographic automata systems (GAS) including cellular automata (CA) and agent-based models (ABM) are spatio-temporal modelling frameworks that are rooted in complex systems theory. In a similar manner, network theory uses a complex systems approach to represent

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and analyze spatial systems as sets of georeferenced nodes and links that form measurable spatial networks. Separately, GAS and network-based approaches offer unique advantages in exploring and analyzing complex systems, however the two approaches are rarely integrated. Therefore, the purpose of this dissertation is to explore the intersection of complex systems theory, geographic information science, and network theory to leverage the advantages of each field for better understanding a variety of complex spatial systems. The main objective is to develop a suite of novel network-based automata modelling approaches that simulate complex dynamic spatial systems as measurable, evolving, spatial networks. Three novel modelling approaches are developed including: a geographic network automata (GNA) model that uses spatial networks, network-based transition rules, and network analysis for the representation of complex spatial systems; a network-based ABM (N-ABM) that integrates networks not as inputs for the ABM, but as a novel way to conceptualize, analyze, and communicate the model and model results; and a network based validation approach for the testing of ABMs. Obtained results demonstrate that the integration of complex systems theory, geographic information science, and network theory offers new means for the representation, analysis, communication, and testing of GAS and the complex systems they represent, thus helping to thus helping to "open the black box". Furthermore, the presentation of modelling results in application to insect infestation and disease transmission contribute to the enhancement of decision-making processes by

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providing tools that can be used in forecasting and scenario testing. This dissertation contributes new methodological frameworks to the fields of geographic information science, GAS, and network theory.

## **Discrete and Continuous Simulation**

When it comes to discovering glitches inherent in complex systems-be it a railway or banking, chemical production, medical, manufacturing, or inventory control system-developing a simulation of a system can identify problems with less time, effort, and disruption than it would take to employ the original. Advantageous to both academic and industria

## **Cities and Complexity**

Complex systems modeling and simulation approaches are being adopted in a growing number of sectors, including finance, economics, biology, astronomy, and many more. Technologies ranging from distributed computing to specialized hardware are explored and developed to address the computational requirements arising in complex systems simulations. The aim of this book is to present a representative overview of contemporary large-scale computing technologies in the context of complex systems simulations applications. The intention is to identify new research directions in this field and to provide a communications platform facilitating an exchange of concepts, ideas and needs between the scientists and technologist and

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complexsystem modelers. On the application side, the book focuses on modeling and simulation of natural and man-made complexsystems. On the computing technology side, emphasis is placedon the distributed computing approaches, but supercomputing andother novel technologies are also considered.

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