

Springer Complexity

Springer Complexity is an interdisciplinary program publishing the best research and academic-level teaching on both fundamental and applied aspects of complex systems – cutting across all traditional disciplines of the natural and life sciences, engineering, economics, medicine, neuroscience, social and computer science.

Complex Systems are systems that comprise many interacting parts with the ability to generate a new quality of macroscopic collective behavior the manifestations of which are the spontaneous formation of distinctive temporal, spatial or functional structures. Models of such systems can be successfully mapped onto quite diverse “real-life” situations like the climate, the coherent emission of light from lasers, chemical reaction-diffusion systems, biological cellular networks, the dynamics of stock markets and of the internet, earthquake statistics and prediction, freeway traffic, the human brain, or the formation of opinions in social systems, to name just some of the popular applications.

Although their scope and methodologies overlap somewhat, one can distinguish the following main concepts and tools: self-organization, nonlinear dynamics, synergetics, turbulence, dynamical systems, catastrophes, instabilities, stochastic processes, chaos, graphs and networks, cellular automata, adaptive systems, genetic algorithms and computational intelligence.

The two major book publication platforms of the Springer Complexity program are the monograph series “Understanding Complex Systems” focusing on the various applications of complexity, and the “Springer Series in Synergetics”, which is devoted to the quantitative theoretical and methodological foundations. In addition to the books in these two core series, the program also incorporates individual titles ranging from textbooks to major reference works.

Editorial and Programme Advisory Board

Péter Érdi

Center for Complex Systems Studies, Kalamazoo College, USA and Hungarian Academy of Sciences, Budapest, Hungary

Karl Friston

Institute of Cognitive Neuroscience, University College London, London, UK

Hermann Haken

Center of Synergetics, University of Stuttgart, Stuttgart, Germany

Janusz Kacprzyk

System Research, Polish Academy of Sciences, Warsaw, Poland

Scott Kelso

Center for Complex Systems and Brain Sciences, Florida Atlantic University, Boca Raton, USA

Jürgen Kurths

Potsdam Institute for Climate Impact Research (PIK), Potsdam, Germany

Linda Reichl

Center for Complex Quantum Systems, University of Texas, Austin, USA

Peter Schuster

Theoretical Chemistry and Structural Biology, University of Vienna, Vienna, Austria

Frank Schweitzer

System Design, ETH Zürich, Zürich, Switzerland

Didier Sornette

Entrepreneurial Risk, ETH Zürich, Zürich, Switzerland

Understanding Complex Systems

Founding Editor: J.A. Scott Kelso

Future scientific and technological developments in many fields will necessarily depend upon coming to grips with complex systems. Such systems are complex in both their composition – typically many different kinds of components interacting simultaneously and nonlinearly with each other and their environments on multiple levels – and in the rich diversity of behavior of which they are capable.

The Springer Series in Understanding Complex Systems series (UCS) promotes new strategies and paradigms for understanding and realizing applications of complex systems research in a wide variety of fields and endeavors. UCS is explicitly transdisciplinary. It has three main goals: First, to elaborate the concepts, methods and tools of complex systems at all levels of description and in all scientific fields, especially newly emerging areas within the life, social, behavioral, economic, neuro- and cognitive sciences (and derivatives thereof); second, to encourage novel applications of these ideas in various fields of engineering and computation such as robotics, nano-technology and informatics; third, to provide a single forum within which commonalities and differences in the workings of complex systems may be discerned, hence leading to deeper insight and understanding.

UCS will publish monographs, lecture notes and selected edited contributions aimed at communicating new findings to a large multidisciplinary audience.

Cyrille Bertelle · Gérard H.E. Duchamp ·
Hakima Kadri-Dahmani (Eds.)

Complex Systems and Self-organization Modelling

 Springer

Professor Cyrille Bertelle
LITIS (EA 4051)
UFR Sciences et Techniques
25 rue Ph. Lebon - BP 540
76058 Le Havre Cedex
France
cyrille.bertelle@univ-lehavre.fr

Dr. Hakima Kadri Dahmani
Laboratoire d'Informatique de l'université
Paris Nord
Institut Galilée
99 avenue J.B. Clément
93430 Villetaneuse
France
hkd@lipn.univ-paris13.fr

Professor Gérard H.E. Duchamp
LIPN - UMR CNRS 7030
University of Paris 13
99 avenue Jean-Baptiste Clément
93400 Villetaneuse
France
ghed@lipn.univ-paris13.fr

ISBN: 978-3-540-88072-1

e-ISBN: 978-3-540-88073-8

DOI 10.1007/978-3-540-88073-8

Understanding Complex Systems ISSN: 1860-0832

Library of Congress Control Number: 2008936468

© Springer-Verlag Berlin Heidelberg 2009

This work is subject to copyright. All rights are reserved, whether the whole or part of the material is concerned, specifically the rights of translation, reprinting, reuse of illustrations, recitation, broadcasting, reproduction on microfilm or in any other way, and storage in data banks. Duplication of this publication or parts thereof is permitted only under the provisions of the German Copyright Law of September 9, 1965, in its current version, and permission for use must always be obtained from Springer. Violations are liable to prosecution under the German Copyright Law.

The use of general descriptive names, registered names, trademarks, etc. in this publication does not imply, even in the absence of a specific statement, that such names are exempt from the relevant protective laws and regulations and therefore free for general use.

Cover design: WMXDesign GmbH

Printed on acid-free paper

9 8 7 6 5 4 3 2 1

springer.com

Preface

The concern of this book is the use of emergent computing and self-organization modelling within various applications of complex systems. We focus our attention both on the innovative concepts and implementations in order to model self-organizations, but also on the relevant applicative domains in which they can be used efficiently.

First part deals with general modelling and methodology as conceptual approaches for complex systems description. An introductory chapter by Michel Cotsaftis entitled “A Passage to Complex Systems”, treats the notion of “Complex Systems” in opposition to that of a “Complicated System”. This can be, he claims, comprehended immediately from the latin roots as “Complex” comes from “cum plexus” (tied up with) whereas “complicated” originates from “cum pliare” (piled up with). The paper is a wide and rich dissertation with elements of history (of the technical developement of mankind) with its recents steps : mechanist, quantum and relativistic points of view. Then, the need for a “passage” is illustrated by the discussion, with tools borrowed from functional analysis, of a typical parametric differential system. The last and conclusive parts give tracks for the study of Complex Systems, in particular one can hope to pass to quantitative study and control of complex systems even if one has to consent a “larger intelligence delegation” to them (as announced in the introduction) by using and developing tools already present in dissipative Physics and in Mathematical functional analysis and fixed point theorems, for instance. This “passage” is followed by a wide bibliography of more than 90 entries. The (non hasty) reader is invited to read this deep and far reaching account before browsing through the book.

The chapter, “Holistic Metrics, a Trial on Interpreting Complex Systems” by J. M. Feliz-Teixeira et al., proposes a simple and original method for estimating or characterize the behaviour of complex systems, in particular when these are being studied throughout simulation. The originality of the chapter lies in the fact that the time/observable space is replaced by the corresponding

variable/observable space (as one does for Wavelet Transforms and in Quantum Mechanics). Next chapter, “Different Goals in Multiscale Simulations and How to Reach Them” by P. Tranouez et al., summarizes the works of the authors on multiscale programs, mainly simulations. They present methods for handling the different scales, with maintaining a summary, using an environmental marker introducing a history in the data and finally using knowledge on the behaviour of the different scales to handle them at the same time. “Invariant Manifolds in Complex Systems” by J.-M. Ginoux et al. shows how to locate, in a general dynamical system (on a 2,3 dimensional variety) remarkable subsets which are flow-invariant. Part I ends with a chapter by Z. Odibat et al. entitled “Application of Homotopy Perturbation Method for Ecosystems Modelling” (HPM). HPM is one of the new methods belonging ranking as one of the perturbation methods. The attention of the reader is focused on the generation of the decomposition steps to build a solver using the HPM method. Concrete solvers for prey-predator systems involving 2 or 3 populations are computed and a special attention is paid on implementation aspects.

Second part deals with swarm intelligence and neuronal learning. We focus our attention here on how implement self-organization processes linked to applicative problems. Both swarm intelligence and neuronal learning give some ways to drive the whole system, respecting its complex structure. F. Ghezail et al. use one of the most efficient swarm intelligence processes, ant colonies method, to solve a multi-objective optimization problem. J. Franzolini et al. present a very promising new approach based on swarm intelligence, immune network systems. They give detailed explanation on the biological metaphor and accurate simulation results. The last chapter of this part, by D.A. El-Kebbe et al., deals with the modelling of complex clustering tasks involved in cellular manufacturing, using neural networks. On the basis of Kohonen’s self-organizing maps, they introduce Fuzzy Adaptive Resonance Theory (ART) networks to claim on their efficiency to obtain consistent clustering results.

Third part entitled “Socio-Environmental Complex Modelling and Territorial Intelligence”, deals with the complexity of systems where space is fundamentally the center of the interaction network. This space interacts on the one hand, with human themselves or their pre-defined or emergent organizations and on the other hand within natural processes, based on living entities inside ecosystems or also on physical features (like in the complex multi-scale phenomena leading to cliff collapse hazards described by Anne Duperret et al.). In the first case, we focus on geographical information systems (GIS) where humans are now able to notify, with an accuracy of location, the material based on their own organization. Even if these GIS constitute an impressive database in static way at a fixed time, they are still not able to reconstitute the complexity of the human organization dynamics and we propose in this book some research developments to lead their evolution toward their inherent complexity. H. Kadri-Dahmani et al. study the emergent prop-

erties from the GIS updating propagation process over an interactive network; R. Ghnemat et al. focus on the necessity of mixing GIS with active processes called agents which are able to generate emergent organization from basic simple rules like in Schelling's segregation model; D. Provitolo proposes a methodology deeply inspired from the complexity concepts, for modelling risk and catastrophe systems within dynamical systems; G. Prevost et al. propose an effective methodology, based on adaptative processes, to mix the two majors classes of simulation: differential approach and individual-based approach. Through the unavoidable expression of the complexity expressed in these different contributions, we can feel how the Complexity Science renovates the modelling approaches, respecting and highlighting the fundamental and classical methods by the "cum-plexus" combination of them to express the whole system complexity, more than by the addition of a long list of complicated scattered sub-systems.

Fourth part deals with emotion modelling within the cognitive processes as the result of complex processes. The general purpose here is to try to give some formal description to better understand the complex features involved in the essential emotion-cognition-action interaction. Decision making is one of the result of this interaction: K. Mahboub et al. study and propose a model to mix in a complex way the emotional aspects in some player choices. In a second paper, S. Baudic et al. propose a relevant approach leading to confront theory and clinical practice to better improve the knowledge of emotion and its interaction with memory (with practical illustration based on Alzheimer's disease) and with cognition (through the fear behaviour). Therapeutic applications can then be implemented from this methodology.

Fifth part deals with simulation and production systems. In that field, Complexity Science gives a new way to model the engineering process involved in some productions systems dealing with the management of a great number of components and dimensions in multi-representation and multi-scale description. The contribution of B. Kausch et al. deals with this complex process, applied to chemical engineering, using Petri nets modelling. The contribution of G. Giulioni claims that self-organization phenomena and complexity theory is a relevant way to model economic reality. This study proposes a model based on the economic result of a large number of firms based on the evolution of capital and the dynamics of productivity. The discussion from output results enlightens the emergence of attractors on the aspects of limit cycles and possible transition to equilibrium. The contribution of A. Dumbuya et al. deals with the complexity of traffic interaction and the development of a driver model based on neural networks. The goal is to improve the behavioural intelligence and realism in driving simulation scenarios.

VIII Preface

This book is the outcome of a workshop meeting within ESM 2006 (Eurosis), held in Toulouse (France) in October 2006, under the efficient organization of Philippe Geril that we would like to thank here.

Le Havre & Paris, France,
April 2008

Cyrille Bertelle
Gérard H.E. Duchamp
Hakima Kadri-Dahmani

Contents

Part I Complex system modelling and methodology

A Passage to Complex Systems

Michel Cotsaftis 3

Holistic Metrics, a Trial on Interpreting Complex Systems

J. Manuel Feliz-Teixeira and António E. S. Carvalho Brito 21

Different Goals in Multiscale Simulations and How to Reach Them

Pierrick Tranouez and Antoine Dutot 29

Invariant Manifolds of Complex Systems

Jean-Marc Ginoux and Bruno Rosseto 41

Application of Homotopy Perturbation Method for Ecosystems Modelling

Zaid Odibat and Cyrille Bertelle 51

Part II Swarm intelligence and neuronal learning

Multi Objective Optimization Using Ant Colonies

Feïza Ghezail, Henri Pierreval, and Sonia Hajri-Gabouj 65

Self-Organization in an Artificial Immune Network System

Julien Franzolini and Damien Olivier 71

On Adapting Neural Network to Cellular Manufacturing

Dania A. El-Kebbe and Christoph Danne 83

Part III Socio-environmental complex modelling and territorial intelligence

The Evolution Process of Geographical Database within Self-Organized Topological Propagation Area
Hakima Kadri-Dahmani, Cyrille Bertelle, Gérard H.E. Duchamp, and Aomar Osmani 97

Self-Organization Simulation over Geographical Information Systems Based on Multi-Agent Platform
Rawan Ghnemat, Cyrille Bertelle, and Gérard H.E. Duchamp 107

Cliff Collapse Hazards Spatio-Temporal Modelling through GIS: from Parameters Determination to Multi-scale Approach
Anne Duperret, Cyrille Bertelle, and Pierre Laville 117

Structural and Dynamical Complexities of Risk and Catastrophe Systems: an Approach by System Dynamics Modelling
Damienne Provitolo 129

Detection and Reification of Emerging Dynamical Ecosystems from Interaction Networks
Guillaume Prévost and Cyrille Bertelle 139

Part IV Emotion and cognition modelling

Simulation of Emotional Processes in Decision Making
Karim Mahboub and Véronique Jay 165

Emotions: Theoretical Models and Clinical Implications
Sophie Baudic and Gérard H. E. Duchamp 177

Part V Production systems and simulation

Complex Systems Dynamics in an Economic Model with Mean Field Interactions
Gianfranco Giulioni 189

Complexity of Traffic Interactions: Improving Behavioural Intelligence in Driving Simulation Scenarios
Abs Dumbuya, Anna Booth, Nick Reed, Andrew Kirkham, Toby Philpott, John Zhao, and Robert Wood 201

**An Integrative Simulation Model for Project Management in
Chemical Process Engineering**

*Bernhard Kausch, Nicole Schneider, Morten Grandt,
and Christopher Schlick* 211

Index 233