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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.

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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, neuroand 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.

M.A. Aziz-Alaoui · C. Bertelle (Eds.)

From System Complexity to Emergent Properties

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Preface

Emergence and complexity refer to the appearance of higher-level properties and behaviours of a system that obviously comes from the collective dynamics of that system's components. These properties are not directly deductable from the lower-level motion of that system. Emergent properties are properties of the "whole" that are not possessed by any of the individual parts making up that whole.

Such phenomena exist in various domains and can be described, using complexity concepts and thematic knowledges. Natural systems in biology and environmental science exhibit wide range of interactions' systems (food chain or neuronal systems, for example) through multi-scale phenomena where each level reproduces similar organizational emergence. Social systems in human or economical sciences exhibit similar kinds of emergent organizations, due to individual behaviour interactions. The dynamics of the components lead the system to organizational evolutions crossed by temporary critical equilibrium, for example bifurcation phenomena.

In this book, we will highlight complexity modelling through dynamical or behavioral systems. We will develop wide range of links between models and various applicative area in geography, urban systems, traffic management, biological systems, ...

Complexity science exhibits original feature by filling the communication gap between thematians (domain experts) who hold specific knowledges of reality and phenomena and modelling designers who hold specific knowledges of some formal operational descriptors, relevant for these reality and phenomena. Complexity leads to efficient ways for thematians to analyze practical phenomena. The thematians' knowledges together with complex systems' concepts, can lead to emphasize innovative properties which can be generalized and formalized through a wide range of domains (resilience, for example ...).

The first chapters of this book focus on complexity modelling concepts. In the first part, historical point of views and conceptual descriptions are given, leading to a better understanding of complexity through epistemology

(F. Varenne) or to a formalization proposal for multi-level emergent behaviours (C.-C. Chen et al.). Fundamental questions are asked: “When are things complex?” (R. Sitte) and “What makes a system complex?” (M. Cotsaftis).

In the second part, complexity modelling is proposed for geographical systems. Deep links of these systems with emergent properties (A. Dauphiné) are presented. Methodological approaches for risk and catastrophe analysis and management are described (E. Daudé et al., D. Provitolo). Innovative swarm intelligence algorithm is proposed for spatial self-organization simulations (R. Ghnemat et al.).

In the third part, dynamics on complex networks are studied. The emergence of chaos in networks describing adaptive systems are investigated (A. Gecow). Synchronization phenomena in neural networks are shown and lead to a power law characterizing self-organized systems (N. Corson and M.A. Aziz-Alaoui). An original validation process is proposed to study the dynamics of distributed architectures, using formal methods (I. Oliver).

In the fourth part, complexity engineering for transportation is studied. Adaptive self-organization processes for transportation on demand in urban systems are described (C. Bertelle et al.). Modelling for network intermodal transport is also given (A. Caris et al.).

In the fifth part, different aspects of engineering processes for decision making are suggested: complex systems’ modelling for inventory management systems (K. Ramaekers and G.K. Janssens), medical diagnosis based on co-operation between physicians and artificial agents (B.L. Iantovics), timetable agent-based software (E. Babkin et al.), emotion modelling for problem solving applied to learning (K. Mahboub et al.).

The pluridisciplinary purposes of this book’s concern are enable to design links between a wide-range of fundamental and applicative Sciences. Developing such links - instead of focusing on specific and narrow researches - is characteristic of the Science of Complexity that we try to promote by this contribution.

Le Havre, France
February 2009

M.A. Aziz-Alaoui
Cyrille Bertelle

Contents

Part I: Concepts for Complexity Modelling

Models and Simulations in the Historical Emergence of the Science of Complexity <i>Franck Varenne</i>	3
About the Predictability and Complexity of Complex Systems <i>Renate Sitte</i>	23
What Makes a System Complex? – An Approach to Self Organization and Emergence <i>Michel Cotsaftis</i>	49
A formalism for multi-level emergent behaviours in designed component-based systems and agent-based simulations <i>Chih-Chun Chen, Sylvia B. Nagl, Christopher D. Clack</i>	101
Emergence of Chaos and Complexity During System Growth <i>Andrzej Gecow</i>	115

Part II: Geographical Complex Systems Modelling

Theory of Reaction-Diffusion and Emergence of the Geographical Forms <i>André Dauphiné</i>	157
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Spatial risks and complex systems : methodological perspectives

Eric Daudé, Damienne Provitolo, Edwige Dubos-Paillard, David Gaillard, Emmanuel Eliot, Patrice Langlois, Eliane Propeck Zimmermann, Thierry Saint-Gérard 165

A new classification of catastrophes based on “Complexity Criteria”

Damienne Provitolo 179

Community Swarm Optimization

Rawan Ghnemat, Cyrille Bertelle, Gérard H.E. Duchamp 195

Part III: Dynamical Artificial or Natural Complex Networks

Emergence of Growth and Structural Tendencies During Adaptive Evolution of System

Andrzej Gecow 211

Complex emergent properties in synchronized neuronal oscillations

Nathalie Corson, M.A. Aziz-Alaoui..... 243

Validation Of A Distributed ‘SmartSpace’ Architecture Through Simulation

Ian Oliver..... 261

Part IV: Transport and Traffic Flow

A Decentralised Approach for the Transportation On Demand Problem

Cyrille Bertelle, Michel Nabaa, Damien Olivier, Pierrick Tranouez ... 281

Modelling Complex Intermodal Freight Flows

An Caris, Gerrit K. Janssens, Cathy Macharis 291

Part V: Decision Support Systems

Modelling the Complexity of Inventory Management Systems for Intermittent Demand using a Simulation-optimisation Approach

Katrien Ramaekers, Gerrit K. Janssens..... 303

Cooperative Medical Diagnosis Elaboration by Physicians and Artificial Agents	
<i>Barna Laszlo Iantovics</i>	315
AgentTime: A Distributed Multi-agent Software System for University’s Timetabling	
<i>Eduard Babkin, Habib Abdulrab, Tatiana Babkina</i>	341
Emotion: appraisal-coping model for the “Cascades” problem	
<i>Karim Mahboub, Evelyne Clément, Cyrille Bertelle, Véronique Jay</i> ...	355
Index	365