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.

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

Springer

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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, trafic management, biological systems, ...

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

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February 2009 *Cyrille Bertelle*

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