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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.

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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.

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

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Complex Systems and Self-organization Modelling

Springer

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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 introductive 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 contitute an impressive database in static way at a fixed time, they are still not able to restitute 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 properties 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 enlights 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.

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