Complex Systems: Chaos and Beyond

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Complex Systems: Chaos and Beyond

A Constructive Approach with Applications in Life Sciences

With 111 Figures

Springer

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Preface

We first had the idea to write a joint book fourteen years ago. First we had intended to write a book on chaos, and then our vision expanded to include the significance of chaos in all fields of science, which exploded to a plan for a dozen-volume series. Since this was not realistic, it did not materialize. Then we made a reduced plan about a decade ago, with explicit outlines, but this did not work out either. In the meantime, our interest has shifted to the study of complex systems, based on, but beyond, chaos. Kaneko made a departure to a 'jungle tour' to search for universal structures in high-dimensional chaos, based on the study of coupled map lattices and globally coupled maps. With concepts and phenomenal he discovered, he started to study life from the viewpoint of a complex system, where life can be viewed as complementarity dynamics itself between the whole and parts. Tsuda proposed a hermeneutic study of the brain and also a dynamic aspect of the brain, taking the information structure of chaos into account. There, he started brain research in order to epistemologically understand chaos, whose essence is regarded as "descriptive instability" and some sort of undecidability.

After this long detour, we finally published the Japanese version of the present book in 1996 with Asakura Publ. Inc. This book is based on the Japanese version, but the contents are updated.

This is neither a textbook on chaos nor a textbook on complex systems. It is not intended to transfer established knowledge, either. Rather, we intend to provoke discussions on complex systems, by showing what we have achieved and what we aim at accomplishing in the field of 'complex systems'.

We take a standpoint that chaos is essential to a practical and philosophical study of complex systems, although the complex systems are such that we must postulate some other concepts beyond chaos. Here we reexamine what concepts in chaos are relevant to the study of complex systems. From this reconsideration, we take the following three standpoints for the study of complex systems: a constructive approach, a many-to-many relationship, and descriptive instability. The last issue is, in particular, based on the observation problem, where we intend to consider seriously what a description of a system means, how descriptions or observations impinge on a system, and then what condition is imposed on a system for stability against descriptions. A clear answer to this issue has not yet been obtained, but we try to provide a basis for future studies.

As people from a variety of fields show interest in the studies of complex systems, there will be diverse ways in reading the present book. Hence we give some possible guidance for readers, so that they are not lost in the jungle of complex systems.

Those who are interested generally in complex systems are recommended to read Chap. 1, and then choose some chapters depending on their interests. Chapter 1 is written so that it can be read as an independent monograph, which we hope will be understandable to the general readership, including nonscientists.

It is recommended that all readers choose some chapters depending on their interests. For example, those who are interested in brain and cognition problems will probably read Chap. 6, but it is hoped that they will also read Chaps. 2–4; while Chap. 5 provides a bridge between these chapters and Chap. 6.

Those who work in the field of statistical physics, mathematical physics, and dynamical systems will find several research topics they should study in the future in Chaps. 2–6. Some topics in these chapters are not yet mathematically refined, but it is hoped that they will be formalized and established as a concrete concept or framework.

Physicists and chemists in general may find Chaps. 2–4 most interesting.

Those who try to understand dynamics in a biological system can find relevant parts in Chaps. 2 and 4 and in a part of Chap. 3, depending on their interests. After scanning these chapters, they will find Chaps. 5 and 6 interesting.

Those who are interested in the engineering applications of chaos and biology-oriented systems, and the search for novel basic ideas, can find some relevant concepts or phenomena throughout Chaps. 2–6.

It is our regret that the translation of this book from Japanese has taken so much longer than we had imagined. Indeed we first looked for a good translator, but in vain. Finally we decided to translate it ourselves. This was a painful decision for us, but there have been some merits, we believe. We have succeeded in updating the contents throughout the book. We revised some vague expressions in Chap. 1 to be more understandable. Chapters 2 and 3 in the Japanese version are joined to form a new Chap. 2, where excessive mathematical discussions have been eliminated. In Chap. 3, we have added some paragraphs on the significance of coupled map lattices, and recent examples of its applications are discussed at length. There are quite recent developments on the collective dynamics in globally coupled maps, which are also included in Chap. 4. Of course, the core of complex systems lies in a biological system, and our recent studies focus on this direction. In Sect. 5.6, we have outlined recent studies on theoretical (cell) biology along the lines of Chap. 1. In Chap. 6, we deleted some lengthy explanations that appeared in the Japanese version, and instead added a concise description. Recent studies about a temporal coding were additionally introduced and their references were updated. Besides these major ones, minor revisions have been carried out throughout the book.

Although we do not list all the names as is usually done, we would, of course, like to give sincere thanks to all the collaborators and those who have shared interest in the topics of this book for their stimulating discussions. We heartily express our gratitude to Dr. Frederick Willeboordse who kindly took care of a critical reading of the mansucript and the correction of the English.

Tokyo and Sapporo
July 2000

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