Complex Systems-Operational Approaches

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H. Haken, Ed. *Complex Systems–Operational Approaches in Neurobiology, Physics, and Computers: Proceedings of the International Symposium on Synergetics at Schloss Elmau, Bavaria, May 6–11, 1985.* Springer-Verlag, Berlin, Heidelberg, New York, Tokyo, 1989, 365 pp.

This symposium is one of the "Springer" series of books on synergetics. In the spirit of the previous editions, much attention is also given in this volume to collective phenomena in complex systems, when one can use a small number of controlling macroscopic parameters, below which other degrees of freedom are arranged (the principle of "slaving"). This time the discussion is about really complex systems, which can consist of an enormous number of active elements and can, correspondingly, possess a gigantic amount of information. The problem consists of "compressing" this information. For this, a transition to the macroscopic level, i.e., to a study of the properties of the system as a whole, is the most natural approach. The operational approach consists of developing methods to measure the macroscopic characteristics and of describing the behavior of complex systems with subsequent computer modeling of them.

The book contains invited papers at the Symposium on Complex Systems. They are grouped by chapers: 1. Evolution. 2. Functions of the Brain in Man and Animals. 3. Coordination of Motion. 4. Computers and Computing. 5. Theoretical Concepts. 6. Physical Systems; Order and Chaos.

P. Schuster's paper on molecular evolution, in particular, on the study of stochastic phenomena and of the effect of finite population size on the scenario of evolution, is placed in the first chapter. The conditions are investigated as to when selection can occur as a consequence of mutations and reproduction.

Different approaches to studying functions of the brain are discussed in the second chapter, which contains six papers. Some papers are of a purely biological nature, others are grouped with the physics of nonlinear systems. The results of research on the principles of processing visual information, the results of multiple neuron experiments and of the correlation characteristics for the electric oscillations on probes, microelectrodes embedded in the living tissue of the brain, are presented here. Encephalograms are considered as the result of a strange attractor type dynamics, and the fractal dimensionality is measured. The paper by W. Kinzel, in which spin glass is considered as the simplest variant of a neuron network and J. J. Hopfield's model for "teaching" neural networks is explained, is of interest to physicists. The paper by J. C. Eccles on the experimental study of functions of the brain from the point of view of the interaction of mental activity with events in neural networks is of great interest. He shows that quantum phenomena with their probabalistic characteristics can play a role in brain processes, which opens exciting prospects for the development of quantum theory approaches to studying functions of the brain.

Five papers in Chapter 3 are devoted to studying different problems of the coordination of motion, which is considered from the point of view of the synergetic approach, i.e., as a coherent process with the coordinated participation of a large number of dynamic units.

Four papers are placed in Chapter 4. Two of them are devoted to parallel processing in multiple computers. And the two others that are presented by H. Shimizu with his coauthors open new prospects in computer technology on the way to creating artificial intelligence. So-called synergetic computers constructed for dynamic methods of information processing, i.e., for dynamically active elements connected with each other like neurons, are discussed.

Theoretical concepts and certain questions of statistical physics are discussed in Chapter 5. And finally, the sixth chapter, which contains eight papers, is devoted to the questions of order, chaos, and of adaptation in physical systems that are more traditional for synergetics.

The theory of bifurcation in crystal growth processes and in elementary particle physics is explained in detail for many examples in the lecture by C. Geiger and coauthors. Different forms of convection in plane and spherical layers of fluid are considered in two papers by H. Haken and coauthors. Chaos in a fluid during its parametric excitation is studied in the paper by E. Meron and I. Procaccia, and the paper by G. A. Held and C. D. Jeffries is devoted to the study of chaos in a so-called oscillistor, a semiconductor oscillation generator. In the paper by Yu. L. Klimontovich, the author's opinion on the structure of turbulence as an adaptation process is explained, and a somewhat different opinion on turbulence is presented in the paper by S. Grossmann. Different regimes for generating oscillations in free electron lasers are described in the paper by R. Bonifacio and F. Casagrande.

This symposium, just as the other symposia of the "Springer" series on synergetics, is primarily of interest because it shows the kindred nature of the approaches to complex systems and to complex phenomena in the most diverse fields of science, in this case, in physics, neurobiology, and in computer technology. It certainly gives much food for thought and opens prospects for new, interesting research.

Translated by Frederick R. West

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