PREFACE

This treatise presents a new paradigm of EMERGENCE and COMPLEXITY, with applications drawn from numerous disciplines, including artificial life, biology, chemistry, computation, physics, image processing, information science, etc.

CNN is an acronym for *Cellular Neural Networks* when used in the context of brain science, or *Cellular Nonlinear Networks*, when used in the context of emergence and complexity. A CNN is modeled by *cells* and *interactions*: *cells* are defined as dynamical systems and *interactions* are defined via coupling laws. The CNN paradigm is a universal *Turing machine* and includes cellular automata and *lattice dynamical systems* as special cases.

While the CNN paradigm is an example of REDUCTIONISM *par excellence*, the true origin of emergence and complexity is traced to a much deeper new concept called *local activity*. The numerous complex phenomena unified under this mathematically precise principle include *self organization*, *dissipative structures*, *synergetics*, *order from disorder*, *far-from-thermodynamic equilibrium*, *collective behaviors*, *edge of chaos*, etc.

The central theme of this treatise asserts that the somewhat fuzzy notions of "emergence" and "complexity", as well as their various metamorphosis, such as those cited above, can all be rigorously explained by a precise scientific paradigm abstracted mathematically from the principle of conservation of energy; namely, a *CNN* operating near the *edge of chaos*, where the cells are not only *locally active*, but also *linearly asymptotically stable*. In particular, constructive and explicit mathematical inequalities are given for identifying the region in the CNN parameter space where complex phenomena may emerge, as well as for localizing it further into a relatively small parameter domain called the edge of chaos where the potential for emergence is maximized.*

The content of this monograph is based on a lecture presented at a workshop entitled "Visions of nonlinear science in the 21st century," held in Seville, Spain on 26 June 1996, the proceedings of which is published as a

*For an in-depth application of this provocative new theory, see R. Dogaru and L. O. Chua, "Edge of chaos and local activity domain of FitzHugh-Nagumo Equation," *International Journal of Bifurcation and Chaos*, Vol. 8, No. 2, 1998.

theme issue of the *International Journal of Bifurcation and Chaos*, Vol. 7, No. 10, 1997. As already pointed out in the opening remark of that lecture, the key idea of connecting "complexity" with the hitherto unrelated concept of "local activity" was born the day before the lecture on a sandy beach of Costa del Sol while the author was brainstorming for what would turn out to be a historic lecture.

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I alone, however, am responsible for whatever oversights and shortcomings of any aspects of this book.

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