*BioSystems*, 22 (1989) 341 – 342
Elsevier Scientific Publishers Ireland Ltd.



# Book Review

## Real Brains, Artificial Minds

by John Casti and Anders Karlqvist, Editors, North-Holland, New York, 1987, 226 pages (US$51.25).

One of the main objectives of the book, as stated by the editors, is to present "a good account of the current value of the machine metaphor for the brain's cognitive functions." The book succeeds in illuminating many important aspects of this metaphor, ranging from the relationship between formal models of machines and fundamental aspects of the systems modeled, to specific design strategies for the simulation and implementation of artificial devices with powerful information processing and pattern recognition capabilities.

On the theoretical side, Robert Rosen points to basic limitations of purely "syntatic" representations as a means of modeling aspects of the physical world. In this respect, Rosen maintains that the Church-Turing thesis fails precisely in those cases in which real dynamics cannot be encoded into strings to be processed syntactically. Rosen also points to subtle, but important, conceptual differences between the notions of modeling and simulation.

Otto Rossler analyzed the potential role of endophysics in the study of issues such as particle indistinguishability and the differences that may result in the interpretation of a system's behavior as observed from within the system or by an outside observer.

John L. Casti analyzes the relationship between structure using the framework of mathematical systems theory. Casti shows that there is a formal equivalence between the behavioral and the cognitive schools of psychology, but that this equivalence does not hold at the operational level. By "cognitive school" of psychology is meant the one that accepts, and attempts to explain, the internal structure of the brain. The behavioral school, on the other hand, looks at the brain as a black box, focusing primarily on the relationship between inputs and outputs. Casti shows that linear systems theory is compatible with certain concrete models about brain function, memory and thought processes, including the models of Hoffman, Grossberg and Pribram models.

From a comptuer science perspective, Peter Deussen argues that the "rules paradigm" is the underlying basis for most artificial intelligence applications. According to Deussen, AI is bounded by the power of the rule paradigm itself. What rule is to be selected to be applied in a particular situation is, however, the most difficult aspect of the application of the rule paradigm.

Also form a computer science perspective, John Hallam proposes a computational theory paradigm as a means of investigating cognitive processes at the computational, algorithmic, and implementation levels. Hallam shows the usefulness of this paradigm in the analysis of formal models and theoretical issues, as well as in the analysis of algorithmic and implementation aspects.

Egecioglu, Smith, and Moody's chapter studies the computational capabilities and computational complexity for important types of neural networks. They report on the progress made from the original perceptrons, seen as single layer networks of linear threshold functions, to networks of semilinear activating functions, and Hopfield networks. They notice the limitations of presently available analytical tools for the study of the computational capabilities of massively parallel systems of complex components and favor experimental investigation in computer science.

Gunther Palm's chapter proposes concrete features and mechanisms for the storage and retrieval of information in neural networks. The main theme is associative memories. But the idea of modeling natural network structures and at the same time deriving concepts which are operational for technical memory devices is an underlying basis for the analysis.

Peter Arhem tackles the issue of whether it is possible to study biological intelligence by studying artificial intelligence and points to the inability of formal models to capture all aspects of brain function. In particular, the lack of emphasis in AI on the role of the brain as controller of all aspects of behavior is stated as a reason for the limited contribution of AI to neurophysiological experiment.

Finally, Michael Conrad shows that it is possible to look at the brain as being composed of enzyme-driven neurons with powerful, adaptable pattern recognition capabilities. He also presents specific design strategies for molecular computers and points to fundamental differences between molecular and digital computers. Conrad's tradeoff principle asserts that some important computational capabilities will be unobtainable in artificial systems, unless it is possible to devise the required materials. Conrad maintains that it is infeasible and unnecessary to fabricate an artificial brain that duplicates human intelligence. He concludes that it is far more likely that we can approach human intelligence in a practical way with synthetic systems built out of biology-like materials than that we can create functional equivalents of intelligence with electronic (digital) computers.

In closing, we can say that, as is probably expected in a book covering so broad a subject, many important aspects are not given any noticeable attention. However, as the foregoing review indicates, a number of important issues and valuable insights emerge from the collection of viewpoints expressed in the book.

*Roberto R. Kampfner*
School of Management and
Computer and Information Science
The University of Michigan-Dearborn
Dearborn, Michigan 48128