Arthur S. Iberall Distinguished Lecture on Life and the Sciences of Complexity

December 7, 2007 ⌘ University of Connecticut ⌘ 4:00-5:30 p.m.

Alvin M. Liberman Room, Bousfield Psychology Building

Complex Systems, Self-Organization and Emergence through Measurement: A Study in Semantic Modeling

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Abstract

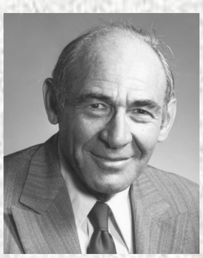
In recent years engineering design and control have reached a critical point where it is possible to design and construct complex systems that exceed our capacity for control (e.g., health care systems, world-wide coupled stock/economic markets, air traffic control systems, national electoral systems, world-wide food production and distribution systems, instabilities in sub-prime financial markets, etc.). Both the structure ("anatomy") and functionality ("physiology") of the parts can exhibit non-stationarity. These complex systems are self-organizing semantic systems.

The first part of the lecture will provide a methodology for exploring the functional (physiological) and structural (anatomical) properties of a complex semantic system. Different classes of parts will be distinguished as to whether the function and/or structure of the part changes with its context. At one extreme, function is always localized in the part's structure; at the other extreme, function is determined by the part's environmental context. From a modeling perspective the structural extreme is the starting point for building syntactic models (with context-free functionality); the environmental extreme is the starting point for building semantic models (with context-sensitive functionality). A construction of a modeling pipeline that connects syntactic models to semantic models will be outlined.

The second part of the lecture will focus, in tutorial fashion, on the engineering problem of how to design and fabricate a self-organizing system. The system involves a high voltage (electron) field, a set of 1500 independent parts (copper balls), and a coupling mechanism (oil). When connected, the system functions as an electrical distribution system. In its initial near-equilibrium condition the system distributes electricity throughout the parts using a "wireless field distribution method" (in the manner originally proposed by Nikola Tesla). As the system is driven from equilibrium it begins to assemble a dendritic-like copper wiring system that locally distributes the electricity (in the manner originally proposed by Thomas Edison). When driven even further from equilibrium the network will begin spontaneously to discharge local impulses of electricity. This example will be used to demonstrate many of the conceptual issues concerning part functionality in a semantic system.

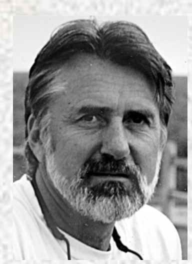
The final part of the lecture will examine the use of measurement linkages as the coupling mechanism between parts of a complex semantic system. It will address how the constraints of a measurement linkage can interact with the properties of the object (part) being measured so as to result in the emergence of new observables—semantic emergence through measurement. Several demonstrations from visual and auditory perception will be presented. This type of emergence can also occur in the measurement linkages of engineering (command and control) systems where it can result in unstable control situations (such as the 1979 accident at Three Mile Island nuclear facility).

This lecture will honor twenty-five years of wonderful memories and five years of daily lunch conversations with Arthur Iberall while we were both members of the Engineering Department at UCLA (1980-1985).



ARTHUR S. IBERALL DISTINGUISHED LECTURE SERIES

Dedicated to the exploration of connections between physical processes and their manifestations in nature, life, humankind, mind, and society. The series honors the physicist, Arthur S. Iberall (1918-2002), whose intellectual legacy includes homeokinetics, a method of applying the laws of thermodynamics to all self-organizing systems. His applied research contributed significantly to the development of the first space suit, the high-speed dental drill, stove surface burners, the fancy-stitch sewing machine, and the electric knife.



Peter N. Kugler has taught at Columbia University, University of Connecticut, UCLA, University of Illinois and, most recently, at Radford University where he held the Dalton Professorship in Computer Science and an Eminent Scholar appointment by the Commonwealth of Virginia. His appointments have been in Kinesiology, Psychology, Engineering and Computer Science. His published work has focused on problems related to self-organization, emergence through measurement, and semantics. He currently works as a contract engineer (Air Force, Navy, Aptima, General Dynamics, World Bank).