What are Cybernetics and Systems Science?

Author
F. Heylighen, C. Joslyn, V. Turchin,

Date
Oct 27, 1999 (modified)
Oct 1, 1993 (created)

Cybernetics and Systems Science (also: "(General) Systems Theory" or "Systems Research") constitute a somewhat fuzzily defined academic domain, that touches virtually all traditional disciplines, from mathematics, technology and biology to philosophy and the social sciences. It is more specifically related to the recently developing "sciences of complexity", including AI, neural networks, dynamical systems, chaos, and complex adaptive systems. Its history dates back to the 1940's and 1950's when thinkers such as Wiener, von Bertalanffy, Ashby and von Foerster founded the domain through a series of interdisciplinary meetings.

Systems theory or systems science argues that however complex or diverse the world that we experience, we will always find different types of organization in it, and such organization can be described by concepts and principles which are independent from the specific domain at which we are looking. Hence, if we would uncover those general laws, we would be able to analyse and solve problems in any domain, pertaining to any type of system. The systems approach distinguishes itself from the more traditional analytic approach by emphasizing the interactions and connectedness of the different components of a system. Although the systems approach in principle considers all types of systems, it in practices focuses on the more complex, adaptive, self-regulating systems which we might call "cybernetic".

Many of the concepts used by system scientists come from the closely related approach of cybernetics: information, control, feedback, communication... Cybernetics, deriving from the Greek word for steersman (*kybernetes*), was first introduced by the mathematician Wiener, as the science of communication and control in the animal and the machine (to which we now might add: in society and in individual human beings). It grew out of Shannon's information theory, which was designed to

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optimize the transmission of information through communication channels, and the feedback concept used in engineering control systems. In its present incarnation of "second-order cybernetics", its emphasis is on how observers construct models of the systems with which they interact (see constructivism).

In fact, cybernetics and systems theory study essentially the same problem, that of organization independent of the substrate in which it is embodied. Insofar as it is meaningful to make a distinction between the two approaches, we might say that systems theory has focused more on the *structure* of systems and their models, whereas cybernetics has focused more on how systems *function*, that is to say how they control their actions, how they communicate with other systems or with their own components, ... Since structure and function of a system cannot be understood in separation, it is clear that cybernetics and systems theory should be viewed as two facets of a single approach.

This insight has had as a result that the two domains have in practice almost merged: many, if not most, of the central associations, journals and conferences in the field include both terms, "systems" and "cybernetics", in their title. In spite of this lack of strict subdivisions, though, the domain is rather fragmented, with many different approaches, similar in some respects, different in others, existing side-by-side. Many of these "schools", such as autopoietic systems, anticipatory systems, living systems, viable systems or soft systems, are associated with a particular theorist or thinker, respectively Maturana, Rosen, Miller, Beer and Checkland. As a result, the cybernetics and systems domain lacks clear foundations. Yet, we, in the Principia Cybernetica Project, believe that the commonalities are much larger than the differences, and therefore it is worth attempting to integrate the different approaches in a common conceptual framework.

Some excellent, easy to read, introductory books on cybernetics and systems can be downloaded freely from our Principia Cybernetica library. Together with our dictionary, and bibliography of basic books and papers, this should be sufficient for an introductory course in the domain. The following links to other websites provide further introductory material and references.

Outside links:

- Alan Scrivener's Curriculum for Cybernetics and Systems Theory

- Felix Geyer's excellent review paper on cybernetics and its applications to social systems
- General Systems Theory and Earth Science: an introduction to systems thinking
- Paul Pangaro's definition of Cybernetics in the Macmillan Encyclopedia of Computers
- an introduction to systems thinking, (especially systems dynamics) by Gene Bellinger
- general information on cybernetics from the ASC
- the ISSS project developing a primer on systems science
- Educational Cybernetics: a course by Gary Boyd at Concordia University
- description of an introductory course on Cybernetics and Systems Theory
- another course description on Systems Theory
- a digest of systems theory, consisting of excerpts from basic books and papers
- Systems Science Archives (mostly French) of the European Systems Union
- Chris Lucas' introduction to 'Cybernetics and Stochastic Systems'

Discussion

- On Norbert Wiener, comment by Mindy McAdams
- man/machine interfaces, Comment by wyatt a. reader-m.a.Firstname Lastname
- You guys are missing the BIG ONE - Wolfram, Comment by Cort Wrotnowski
- You guys are missing the BIG ONE - Wolfram, Comment by Cort Wrotnowski
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