GEORGE J. KLIR

Facets of Systems Science

Kluwer, New York, 2001.
740 pages.
ISBN 0–306–46623–6.

The second edition of Professor Klir's "Facets of Systems Science" is a most welcome addition to the systems literature. The book has benefited significantly from Professor Klir's decade of experience in using the first edition as the text for a graduate level introduction to systems science. While the bulk of the text is taken from the first edition, the second edition offers several significant improvements. The chapters are better divided into subchapters which make the key concepts stand out more clearly. This is important for leaving the reader with a more coherent view of what systems science is. Most importantly, Professor Klir has added a number of exercises to the end of each chapter. The exercises take the text to a new level by lending concreteness to the concepts. For the last decade, those of us interested in systems science have been indebted to Professor Klir for the writing of Facets. Nowhere else is such a clear and pedagogical overview of the field available in one place. That indebtedness is only deepened with the issuing of the second edition.

Facets is divided into two parts. Part I is a conceptual introduction to systems science along with an overview of its historical development. The conceptual overview achieves a balance between some of the mathematical foundations of systems science and a more literary exploration of its major ideas. The mathematics covered will be easily understood by anyone familiar with basic college math. Though the mathematical overview is a valuable aspect of Facets, the non-mathematical portions of the text stand alone. Part II is a treasure-trove of 37 papers from the classical systems literature. Many of the references from Part I are included in the papers in Part II. This provides the reader with the opportunity to immediately follow up on any references of interest. While both parts of Facets are of great value independent of one another, together they constitute further evidence that the whole really is often greater than the sum of the parts. While the importance of Part II should not be underestimated, the remainder of this review concerns itself primarily with Part I.

The conceptual overview (Part I) begins with the oft asked question, "What is systems science?" Professor Klir reminds us that when we speak of systems, we are almost always speaking of some particular system. We might, for instance, be considering a physical system, biological system or social system. Using the example of a library, Professor Klir points out that a heap of books is not in and of itself a system. It is not until the books are ordered according to a particular scheme that the books become a part of a system. From this perspective any given system can be described as a collection of things together with a set of relationships between these things. This is the basis for Klir's notation

$$\mathbf{S} = (T, R).$$

Quoting Klir with respect to this notation, "$\mathbf{S}, T, R$ denote, respectively, a system, a set of things distinguished within $\mathbf{S}$, and a relation (or, possibly, a set of relations) defined on T. Clearly, the thinghood and systemhood properties of $\mathbf{S}$ reside in T and R, respectively." (p. 5) Having defined the concept of system Klir then identifies the domain of inquiry of systems science to be those aspects of systems that derive from the systemhood properties of systems as opposed to a systems thinghood properties. In the example of the library, the system scientist is interested in the ordering of the books rather than in the books themselves.

Chapter 2 begins with a set-theoretic expansion upon the common-sense definition of systems presented in Chapter 1. Readers familiar with set theory will probably have already noted parallels between Klir's notion of systemhood properties and the abstract properties of sets. Klir concurs and he uses the language of set theory to give a mathematical treatment of the notion of relations. For those who might feel that this purely mathematical treatment of systems is too limited, Klir states that, "The fact that we discuss the meaning of this symbol solely in terms of mathematical relations is no shortcoming. The well-defined concept of a mathematical relation [...] is sufficiently general to encompass the whole set of kindred concepts that pertain to systemhood." (p. 12) The second part of Chapter 2 is an epistemological discussion of systems. Klir's view is that systems are mental constructions and that they do not exist in the real world independent of the human mind. Klir's quote of Humberto Maturana, "We do not distinguish what is, but what we distinguish is," (p. 23) aptly summarizes Klir's view. Klir returns to the language of set theory to conclude Chapter 2 by introducing the notion of equivalence relations and isomorphic systems as tools for systems classification.

Chapter 3 is an excellent review of the systems movement covering both its history and motivations. It would make a fine monograph all by itself. The main points covered by Klir are: problems of organized complexity and how the advent of computers has facilitated investigation into this problem domain; holism and reductionism; general systems theory; cybernetics and operations research. Klir concludes Chapter 3 with an important point about systems science representing a new dimension in science. Based upon his earlier distinction between thinghood and systemhood, Klir argues that systems science is orthogonal and complementary to classical science. The divisions of classical science are roughly along the lines of the particular things that are studied. Biologists study organic life, physicists study materials and chemists study chemical reactions. Systems science, with its focus on systemhood properties, is not a new scientific discipline in the traditional sense. It is a sort of meta-science, investigating the systemhood properties of the sciences themselves. Klir argues that the advent of systems science parallels the transformation of our society from an industrial economy to an information based economy.

Chapters 4 to 7 put meat on the bones of mathematical, philosophical and historical skeleton laid out in Chapters 1 to 3. Chapter 4 is an overview of different conceptual frameworks that have been used to classify systems. Klir groups these approaches into two main categories - deductive (starting with axioms and working down to properties of individual systems) and inductive (collecting various systems and abstracting their systemhood properties). The bulk of the chapter is devoted to Klir's own conceptual framework known as the General Systems Problem Solver (GSPS). Chapter 5, "Systems Methodology", presents various methods for addressing systems problems that arise within a given conceptual framework. This chapter contains a valuable discussion of systems modeling. In particular, it addresses the important step of applying interpretations to mathematical models. The implications of interpreting mathematical models are significant and, unfortunately, too often ignored. Chapter 5 also reiterates the role of the computer as the primary methodological tool of systems science. Chapter 6, "Systems Metamethodology", takes a higher level look at systems methodologies and introduces the notion of methodological paradigms. Klir points out that the methods that we employ in our investigations have implications for what possible solutions we might find and he argues that it is critically important to evaluate our methodological assumptions. Klir also makes an important point in chapter 6 regarding a distinction between applied mathematics and systems science. Klir argues that systems methodologies are focused on problems whereas applied mathematics is more typically focused on methods. Quoting Klir, "It is the most fundamental commitment of systems methodology to develop methods for solving general systems problems in their natural formation. Simplifying assumptions, if unavoidable, are introduced carefully, for the purpose of making the problem manageable and, yet, distort it as little as possible." (p. 110) Finally, in Chapter 7, "Systems Knowledge", Klir argues that knowledge obtained in systems science is fundamentally different from knowledge in traditional science. Systems knowledge, according to Klir's constructivist view is "knowledge concerning knowledge structures." (p. 123)

Having established that systems science is indeed a science (it has its own body of knowledge, methodology for acquiring new knowledge and methodological paradigms that guide its investigations), Klir moves on to discuss several special topics that are of particular importance in systems science. The titles of Chapters 8 to 10 speak for themselves. They are, respectively, "Complexity", "Simplification Strategies" and "Goal-Oriented Systems." Klir concludes Part I of Facets with Chapter 11, "Systems Science in Retrospect and Prospect." Klir begins this chapter with an even-handed review of various criticisms that have been leveled at systems science over the last half century. While Klir concurs with some of the criticisms, he adequately addresses each of them in turn. He also reviews the impact that systems science has had upon the sciences and comments on its prospects for the future. Klir's views on these topics derive from his broad conception of what systems science is. He sees that systems science, especially its cross-disciplinary orientation, has had significant impact on many of the sciences. Klir sees the future of systems science as primarily concerned with problems that are beyond our information processing capacities, that is, problems of organized complexity. As such, advances in systems science are likely to be closely aligned with advances in computing power.

This reviewer does not know of any living proponent of systems science that has done more to establish the field on rigorous foundations and to present it as an integral and coherent body of work. One is struck in reading Facets at just how monumental of an undertaking this is on the part of Professor Klir and at what systems science is up against in increasing its recognition and support. Not only does systems science not fit neatly into any of the presently accepted divisions of the sciences, its objects of study are not things in the familiar sense of the word. As Klir presents it, systems science represents a new dimension of science. As such, it requires a new kind of thinking just to comprehend it. As we all know, new paradigms in science are hard won. If systems science truly is the new dimension in science that Klir speaks of, we should not be surprised for it to take a century for it to become widely recognized. A century is, after all, a brief period of time in the intellectual history of mankind.

In conclusion, I would like to suggest that a close study of Facets is likely to benefit anyone that is interested in gaining new insights into scientific inquiry itself as well as new methods for investigating problems of individual interest.

Thanks Professor Klir!

Richard M. Smith