Book reviews

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Facets of Systems Science

Second Edition.
ISFR International Series on Systems Science and Engineering, Volume 15.
Kluwer Academic / Plenum Publishers, New York – Boston – Dordrecht – London – Moscow 2001.
xviii + 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

MICHAEL MESTERTON-GIBBONS

An Introduction to Game–Theoretic Modelling

Second Edition.
American Mathematical Society, Providence, R.I. 2001.
368 pages.
ISBN 0-8218-1929-1.

The referred book is the item No. 11 of the AMS series titled Students Mathematical Library, and its content corresponds with this classification. It offers an informative introduction of a beginner into the world of the mathematical game theory and its intellectual approach to the mathematical modelling of human strategical behaviour in the conflicts of interests.

The book is divided, after the introductory section named *Agenda*, into seven chapters. Each chapter starts with the heuristic analysis of some practical conflict situation, and with its mathematical model. These models are discussed and generalized such that the generalization naturally develops into formal presentation of one of the game theoretical fundamental concepts. These concepts and their properties are investigated. Finally, each chapter is concluded by several (except Chapter 3, more than twenty) usually rather theoretically oriented exercises. Their solutions are summarized in one of the two appendices of the book.

Particular chapters are focused on some of the main types of the strategical or cooperative games, where, namely, Chapters 1, 2 and 6 deal with strategical games, Chapters 3 and 4 study the cooperative model of conflict and in Chapter 5 both views are rather combined.

In rather more detailed summary, Chapter 1, headed "*Noncooperative Games*" introduces the concepts of Nash equilibria and max-min strategies, Chapter 2, "*Evolutionary Stability and Other Selection Criteria*", presents the Harsanyi and Selten criterion, Kalai and Samet criterion and Maymard Smith criterion as well as population games and some other related topics. Then, Chapter 6 is oriented to the analysis of "*More Population Games*", where some specific types of these games are treated. The cooperation models are investigated in Chapter 3, headed "*Cooperative Games in Strategic Form*", where the concepts of unimprovability, Nash bargaining solution and independence of strategies are explained, and in Chapter 4, "*Characteristic Function Games*" in which the most common concepts related to games with transferable utility, like core, Shapley value, and some others, are presented. Chapter 5, named "*Cooperation and the Prisoner's Dilemma*," combines the strategical and cooperative features of conflict situations, and offers an analysis of their mutual position in the model of conflict. The book is concluded by the two appendices devoted to the tracing procedure of association a unique Nash equilibrium with all tentative solutions of a noncooperative game, and to the survey of solutions of exercises. The representative "*Bibliography*" (244 items) and the "*Index*" complete the text.

The book is written clearly, with sympathetic respect to the needs of a reader who approaches for the first time to the mathematical game theory, wishes to understand its motivation and heuristic background of its methods, and having, also, a rather moderate motivation regarding the using of complicated or more advanced mathematical apparatus. For such readers the book offers a very useful introduction into the problem, and it can be effectively used also by teachers who look for an attractive method of presentation of the basic ideas of the game theory to their students.

Milan Mareš

STEVE ALPERN, SHMUEL GAL

The Theory of Search Games and Rendezvous

Kluwer Publishing Company, Boston - London - Dordrecht 2003.
320 pages.
ISBN 0-7923-7468-1.

The theory of pursuit differential games includes numerous special views on the choice of continuous trajectories optimizing in some sense the behavior of the player in question. The most usual case is the game of two players, here they are called Searcher and Hider, which are dealt also in the referred monograph. It distinguishes between two types of the two-players pursuit games differing in the motivation of the Hider. These two types are analyzed in two main sections, called **"Books"**, of the publication. In both of them, the Searcher aims to minimize the time of searching and to meet the Hider as soon as possible.

In the first Book devoted to the *"Search Games"*, the Hider is antagonistic to the Searcher, and his goal is to maximize the search time. The second Book titled *"Rendezvous Theory"* follows from the assumption that the interests of both players are identical and the Hider prefers to shorten the search time, too. The volume is completed by a list of *"Frequently Used Notations"*, a representative *"Bibliography"* (240 items) and the *"Index"*.

The search games are in Book I, after a brief *"Introduction"*, divided into two groups represented by two main parts of the first Book. Namely, the *"Search Games in Compact Spaces"* in which the area of the searching is bounded, and the *"Search Games in Unbounded Domains"*. In Part One, the *"Search for an Immobile Hider"* (including search in network or on a tree, so called "Random Chinese Postman Tour" problem, some aspects of dynamic programming, and other related topics) the more elementary formulation of the considered problem is investigated. The next chapter, *"Search for a Mobile Hider"* (with sections devoted to search on arcs and circle, quick search or search in two dimensions, with various modifications and extensions) deals with the more complicate version of the search problem, and the last chapter *"Miscellaneous Search Games"* closes this part. Part Two, named *"Search Games in Unbounded Domains"* is, similarly to Part One, introduced by *"General Framework"* of the model and then divided into three further chapters, devoted to *"Minimax Properties of Geometric Trajectories"*, to *"Search on the Infinite Line"* (dealing with linear search problem, search with a turning cost, search with uncertain detection, dynamic programming algorithm and some other related topics), and *"Star and Plane Search"* (with star search problem, search on the boundary of a region, search on the plane, and other special models of that sort).

The rest of the volume, Book II, *"Rendezvous Theory"*, is after two introductory chapters presenting *"Introduction to Rendezvous Theory"* and *"Elementary Results and Examples"* divided into two parts, as well. Similarly to Book I, even in this case these parts distinguish the methods due to the type of the domain of searching. Part Three, *"Rendezvous Search on Compact Spaces"*, includes four chapters focused on *"Rendezvous Values of a Compact Symmetric region"* (with special attention on the phenomenon of symmetry), *"Rendezvous on Labeled Networks"*, on *"Asymmetric Rendezvous on Unlabeled Circle"* (oriented to the concepts of symmetry and asymmetry in circles) and *"Rendezvous on a Graph"* (briefly summarizing the results on asymmetric and symmetric rendezvous on some types of graphs). The remaining Part Four, *"Rendezvous on Unbounded Domain"* is divided into three chapters devoted to *"Asymmetric Rendezvous on the Line"* (with the models of player-asymmetric rendezvous, double linear search, maximization of the meeting probability, atomic, discrete, convex and arbitrary distributions), *"Other Rendezvous Problems on the Line"* (mentioning unequal speeds of searching, player symmetry, bounded

sources, unknown initial distribution, multiplayer distribution, and asymmetric information), and *"Rendezvous in Higher Dimensions"* (including the rendezvous in plane and in more dimensional lattices).

The referred monograph offers a very good and representative survey of the classical, as well as modern, trends and fields of interest connected with the game-theoretically treated concepts and results of the search problem theory. It covers its variability in the domain of searching, preferences of players, and other aspects. The seemingly specific but in fact widely formulated problem is presented in a precise style, with correct mathematical formalism, but also with heuristic comments adequate to the character and structure of particular topics. The text covers general models as well some of their specific cases important for applications and modelling of real situations. Even if the mathematical presentation is formally precise, the reading does not demand more than the basic education in higher mathematics.

The referred book can be recommended to everybody who needs widely conceived survey of this part of the theory of games.

Milan Mareš