Reviews

M.M. GUPTA and E. SANCHEZ (Eds.)
Approximate Reasoning in Decision Analysis
North-Holland, Amsterdam, 1982, 455 pages

R.R. YAGER (Ed.)
Fuzzy Sets and Possibility Theory
Pergamon Press, New York, 1982, 633 pages

E.H. MAMDANI and B.R. GAINES (Eds.)
Fuzzy Reasoning and its Applications
Academic Press, London, 1981, 381 pages

It is well known that as the complexity and human content of a system increases, the observer's ability to make precise and yet significant statements about its behavior decreases. After reaching a certain threshold, precision and relevancy of our descriptions become incompatible attributes. This fact is well known in the philosophy of science. In 1906, Pierre Duhem in a book entitled *La Théorie Physique, Son objet et sa structure* published by Chevalier & Rivière in Paris, makes a distinction between practical facts, which are expressed in vague, qualitative, ordinary language, and theoretical facts, which are expressed in precise, quantitative language. Duhem argues that confidence in the truth of a vague assertion may be justified just because of its vagueness which makes it compatible with a whole range of observed facts. The law of physics can acquire the minuteness of detail only by sacrificing some of the fixed and absolute certainty of common-sense laws. According to Duhem "there is a sort of balance between precision and certainty; one cannot be increased except to the detriment of the other".

After 1965, when Zadeh introduced the fuzzy set as a mathematical model of a linguistic variable, three important achievements can be reported.

First, *the principle of incompatibility* was explained considering the category of fuzzy sets and observing that one can model a synthesis by a pullback in this structure. In this way one can explain the need of abstraction as a need for structural stability. Taking into account the fact that the category of concepts is equivalent with the category of fuzzy sets, one can explain how by getting certainty one loses precision. This is the elegant manner in which humans cope with complexity.

Second, *quantitative analysis with linguistic values* was made possible. A particular methodology – application of quantitative analysis to human systems – appeared in the toolbox of the system analyst. In other words, for the first time it seemed to be possible to use simulation with verbal models in the study of systems where human behavior on the individual level plays an essential role. The great advantage of quantitative models is their built-in facility for consistent deduction of consequences. Physics is an example of a discipline where quantitative analysis has proved an indispensable tool because of its deductive power. In physics this is achieved automatically because the variables are arithmomorphic, i.e. numeric. Their values are numbers. Fuzzy mathematics made possible to use verbal models. In verbal models the variables take values that are not numbers but evaluations, i.e. functions. When a linguistic value is modeled as a fuzzy set, one can use a computer to solve a model expressed in natural language. An old barrier is thus eliminated and linguistic models – dominating social sciences – can now be handled by computers.

Third, *knowledge-based systems*, also known as *expert systems*, are available as computer programs that embody the specialized knowledge and expertise of human experts. A new engineering discipline, knowledge engineering, has emerged from the proliferation of expert systems. The goal of this new discipline is to plan, design, construct and manage expert systems for transfer, utilization and extension of knowledge, including inexact and subjective knowledge, formulated in natural language.

These books deal with such kinds of problems. The key word is *defuzzification*, the translation of imprecise statements in fuzzy sets which are arrays of numbers, easily handled by computers.

North-Holland
Human Systems Management 4 (1983) 137–140

In a recent paper (Fuzzy Sets: Precision and Relevancy) published in G. Lasker (ed.): *Applied Systems and Cybernetics,* vol. 6 (Pergamon Press, 1981), Milan Zeleny presents a critical review of fuzzy theory and research. He says that the principle of incompatibility is not respected and the context dependency of human linguistic labels and corresponding membership functions are ignored. These three books contradict these statements and the reader can judge what is happening. The big effort of the approximate reasoning approach is towards defuzzification. At high levels of complexity, when any description is vague, the use of fuzzy set technology means a way to cope with vagueness. How? By defuzzifying. *To use a fuzzy set as a model of a linguistic value means to defuzzify the model.*

Knowledge systems differ from traditional computer programs in a variety of ways. Based on a radically different system architecture and programming styles, the most visible departure from standard computer systems, is the capability of knowledge systems to interact intelligently with their users.

The argument is that a machine would be judged to be intelligent if its responses could not be judged to be different from human response. The testing process is the imitation game. From this approach, due to Turing, much of what is called artificial intelligence has derived. One result of this approach is the argument that simulation or imitation of intelligence is what is required for endowing machines with intelligence.

Approximate reasoning theory aims to provide new models for implementing knowledge-based systems. The applications reported in these books are thus not only useful as successful studies in themselves but also serve as motivation for the theoretician. The applications reported here emerge from a deep understanding of human communication. The knowledge is derived from human experts and the knowledge base thus created is used for decision making. This knowledge is in linguistic form and the exercise is not merely intellectual but also operationally powerful so that computers can be used.

Forty-four papers in the first book, 47 papers in the second one and 16 papers in the third one are trying to demonstrate that fuzzy set theory will not follow the path of utility theory and that nothing is doubtful in the mathematical superstructure used to represent subjective evaluations. On the contrary, after reading these books the feeling is that fuzzy set theory is a realistic approach, making no fetish of precision in *formulation* of the models, i.e. in the description of complex realities. But formulation is one thing and handling is a different one. Present computers cannot handle linguistic values, and via fuzzy sets one can transform linguistic values in strings of numbers. Why so? Because so far we did not find another way.

Fifty years ago, such abilities as reading typeset manuscripts, adding, subtracting, keeping books (accounting), landing an airplane, would have been considered to require human intelligence. Today, with the knowledge of how to program and construct computers for these tasks, the mystery or magic is gone for us and we do not believe that these functions require only the services of human intelligence. Coping with the fuzziness of human abstraction and reasoning is another task possible to be computerized, and all interested in this topic have to see these books where they can find out how a theory of approximate reasoning gains significance and relevance exactly because *fuzzy sets deal with imprecision in precise terms.*

It is well known that judging the intelligence of humans is an emotional question. As noticed by Tillich, the fact that there is so much discussion about the meaning of words is a symptom of something deeper, something both negative and positive in its import. It is a symptom of the fact that we are in a confusion of language which has hardly been surpassed at any time in history. Words do not communicate to us any more what they originally did and what they were invented to communicate. This has something to do with the fact that our present culture has no clearing house such as medieval scholasticism had. For the scholastic, intelligence (*inter* = between, *legere* = choose) meant ability to know. Nothing else. Let us not be scared any more about artificial intelligence.

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W. MCKELVEY
Organizational Systematics: Taxonomy, Evolution, Classification
University of California Press, Berkeley/Los Angeles, CA, and London, England, 1982, 511 pages

I would like to resist the easy temptation to use superlatives which would not convey the substance of my admiration for this book. I must admit that I was inclined to view it favorably, even before reading it, because like the author, I firmly believe that organizational systematics "is crucial to the orderly profession of organizational science". Organization Theory and related sub-disciplines have been floundering much too long. Witness the innumerable attempts in the last thirty years to rewrite basic management theory without ever changing its content, direction or meaning. Thus we are ready for McKelvey's treatise. Whether it constitutes a paradigm shift "remains to be seen", as he so modestly states.

What is organization systematics? "(It) is the science of organizational differences: the study of differences among the forms of organizational populations, the development of taxonomic theory, the recognition and classification of important differences, and the discovery of how and why the differences came about".

I became personally interested in systematics when attempting to find a taxonomy of systems science. With McKelvey, I quickly became convinced that 'systematics' is not to be considered an outgrowth of sound scientific methods but it is a *prerequisite* to such methods. Most readers will agree, as they try to find regularity, patterns, coherence, consistency and order in whatever scientific domain they study. The need to find taxonomical principles is basic to all our processes of *enquiry* by which we seek to understand, explain, diagnose or predict. We purposely spelled enquiry with 'e' rather than with an 'i', because in his encyclopeadic treatise, McKelvey reviews five principles of enquiry – that which "scientists actually do", "the notions which initiate" and guide the course of a line of research. (The reductive, rational, holistic, anti-principle and primitive principles.) He reviews the history of the life sciences to find these principles in the theories of essentialism, nominalism, empiricism and evolutionalism and opts for a combined evolutionist-empiricist theory of classification for organizational systematics. Empiricism has re-emerged as 'numerical phenetic' or numerical taxonomy with the use of the computer to manipulate known attributes using numerical coefficients of resemblance and clustering.

Step by step, McKelvey builds evidence in support of his theory which culminates in his Natural Selection Model of the Organization Form. This he calls the "population perspective" where "non-manipulable elements of the external environment form a constant pressure on a population and its members", and where "the natural selection process is ever present and continually operating" ... "People do not cause a particular form but they are the means by which variations (enactments and behavior variations) arise". Of course, this theory sets aside human purposefulness and falls on the side of determinism and behaviorism. Hopefully, McKelvey will not be quoted out of context when he states:

"Managers, or other people in organizations, do not have much if any direct control of organizational success – they essentially generate variations, some of which are selected favorably, and a selected organizational form is an accumulation of favorably selected variations".

McKelvey recognized that not "all variations are blind" and that "some may be genuine responses to adaptive demands imposed by an environment". McKelvey's doubts concerning a manager's ability to influence events are not as sacrilegious as they may sound. In spite of claims to the contrary, daily current events confirm the inability of managers to control the fate of organizations, companies, governments and whole economies. They all fail right and left and show that they are rather at the mercy of circumstances than in control of events. McKelvey cites bounded rationality, imperfect information, market exchange processes, complexity and uncertainty as some of the reasons why human activities are "necessary but not sufficient determinants of organizational form".

The reader should not receive the erroneous impression that McKelvey's perspective is yet another paradigm to add to a facetious census reported in the book (there are about 6.7 paradigms per organization theorist!). McKelvey aims high and intends to fashion nothing less than a paradigm shift – a new direction for organizational science.

Whether he succeeds or not is left in the hands of his own evolutionary theory to tell. However, regardless of his prescience, I would like to praise the author's sweeping and comprehensive study. I would dearly enjoy to have to retake a course in Organization Theory based on this text. As McKelvey admits, no such course as yet exists. However, I anticipate that, in the near future, it will be required reading in all social science programs.

This book can be used as the basic text for such a course because it is carefully written, generously documented, rich in substance as well as in wisdom. It contains a good glossary and an extensive bibliography.

In his book, McKelvey shows the distinction which must be made between systematics, the science of diversity, and functional science, the study of uniformity. As he points out, 'organizational systematics' is a search for and description of organizational populations, whereas nearly all organizational science to date has focused on functional science. He looks at many of the traditional models and theories about sources of variation in organizations and concludes that organization theory would be on a stronger theoretical footing if both autogenic and allogenic perspectives were synthesized. He postulates the existence of an "organizational protosystem" that is the counterpart in meaning to the "natural system" of biology and establishes the prerequisites that such a system must fulfill.

He defines the fundamental taxonomic unit as an organizational form in which the activities of technologically interdependent subsystems are pooled toward the accomplishment of the primary task. Taken together, the primary task and the work place–management task define an organization's dominant competence – a concept which finds its counterpart in general systems theory. McKelvey then proceeds to present his organizational evolutionary theory which is adapted from biological theory. He notes that organizational evolution is probably as Lamarckian as it is Darwinian, although the pace of organizational evolution is much faster than biological evolution. He then proceeds to discuss a theory of the origins of branches in the evolution of organizations. He reviews the evolution of organizational forms in ancient Mesopotamia from 10,000 years BC to 1,000 years BC to test the theory that events fit the general model of a family tree and induce a set of specific organizational forms that, if elaborated into modern times, identify a set of hypothetical classes useful as a point of departure for numerical clustering and which offer a test for his evolutionary theory. He defines the concept of Operational Taxonomic Unit (OTU) which represents the list of lowest ranking taxa employed in a particular classification. McKelvey candidly reports that hoping for "the perfect list" is only "a pipe dream". "There is no all-encompassing list, except perhaps for classification at the highest rank categories where OTUs are divisions or classes".

McKelvey boasts of taking what he calls the "Population Perspective" which, in one sweep, encompasses the fields of systematics (taxonomy, evolution, classification) and population ecology. He warns us to constantly remember that his book "is about populations of organizations, not individual organizations":

> "Since populations are fundamental to any science interested in discovering generalizable findings, (the) pursuit of a formal population perspective is fundamental to the florescence of an organizational science".

(For more on McKelvey's *Populations, Natural Selection and Applied Organizational Science,* see *Adm. Sc. Quarterly,* March 1983.)

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