Information Technology for the Welfare of Mankind

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THE PRINCIPAL thrust of activities within the IEEE Systems, Man, and Cybernetics Society is the development and use of the methods of *systems* engineering, together with the strongest of emphasis on *human*–system interaction concerns, for the design of knowledge-based *cybernetic* systems and processes that support human activities in planning, design, decisionmaking, and associated resource allocation.

It is through this thrust that we define the purpose of systems engineering as working with clients to assist them in the organization of knowledge. This organization of knowledge requires methods for knowledge acquisition and representation, as well as utilization. Thus systems engineering activities—and the activities of the IEEE SMC Society—vary from the definition of requirements or specification, to the conceptual and functional design and development of systems. They are much concerned with architectural definition and performance evaluation. These are needed to obtain functional integration, maintainability, reliability, and, perhaps most importantly, the appropriate interfaces that will insure system design for successful human interaction. This human interaction may involve human supervisory control of physical processes, such as the robots that are used in automated manufacturing. It may involve typically cognitive tasks at the operational levels of fault diagnosis, detection, and correction, or at the level of strategic planning.

Thus, contemporary and future research efforts in systems engineering and the Systems, Man, and Cybernetics Society place major emphasis on behavioral factor concerns associated with human–machine interaction, artificial intelligence, software systems engineering, and cognitive science. They are and will be especially concerned with the use of computers in decentralized interactive information repositories, and for the development of analytic, computational, and behavioral constructs that support the design of knowledge bases and cognitive engines for efficient and effective planning, design, and decision support.

Many of these efforts involve decision support and expert system research in specific application areas. An objective that supports all of these efforts is the continued development of systems engineering as an information-science knowledge-based discipline. Much of traditional engineering activity within the IEEE has been concerned with the physical and materials sciences. Systems engineering compliments and enhances traditional engineering activities through its emphasis on the information basis for engineering. Systems engineering efforts allow the integration of the *information basis* for engineering with the traditional *physical basis* for engineering such as to enable the design of technological systems and processes that provide effective, efficient, and explicable support to humans in a variety of specific operational and strategic tasks.

In systems engineering, and within the SMC Society of the IEEE, we are especially concerned with aiding clients in the organization of knowledge for purposes such as design. We have realized that initiative and creativity are best enhanced when the user of an information system is able to self-direct the system towards *skill*-based, *rule*-based, or *formal reasoning*-based assistance rather than having to respond to the dictates of behaviorally insensitive and inflexible software. We must provide for user-directed assistance and for varying levels of imprecision and uncertainty associated with knowledge in the design of change-receptive software. We must not allow the specific nature of the images produced by a computer to create an "illusion of concreteness" that does not correspond to the realities of existing situations. Thus the systems design for human interaction that is systems engineering encourages users to integrate an understanding of what is known with the capacity for self-learning concerning that which is unknown to them. The integrating element that enables this is an appreciation for human physiological and cognitive factors, and the requirements that these impose for the enhancement of human skills and intelligence.

We believe that it is essential to approach knowledge acquisition, representation, and use from a variety of perspectives. Managerial perspectives, based on the intuition that follows so well from experience, may provide excellent guides for action in slowly changing, essentially stable environments. Such skill-based behavior may become increasingly inadequate in rapidly changing environments in which there is limited experiential familiarity and where decision situations, with significant and irreversible consequences, occur frequently. This does not suggest that skill-based experience and intuition are of little or no value. Rather it is a strong demonstration that an integrated approach, which blends skill-based reasoning with formal knowledge-based reasoning, will be of greater value. Such capability is provided by the contemporary information technology that is systems engineering.

There are many needs to bring this potential to fruition. One foremost need is flexible change-receptive software that can cope with imprecision in natural language com-

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munication. A second major need is change-receptive organizations. These organizations must be responsive to changing environments through adaptation, and must be capable of the double-loop self-learning that enhances not only skills, but that is necessary for the determination of the most appropriate way of learning how to learn. To some extent at least, it is possible to provide support towards these ends through recent developments in information technology. To accomplish research that will enhance decision support system and expert system capabilities in this area is the major goal of a great many of our present as well as projected efforts for members of the SMC Society.

The technical activities within the SMC Society are especially concerned with complexity. This complexity is brought about because of the multitude of relations and competing perspectives that surround almost all contemporary issues. Generally, knowledge is imprecise and incomplete. This complexity often requires that many people, with varying experiential familiarity with a particular task, by involved in issue resolution efforts. This brings about yet another complexity that requires aggregation of group efforts, including forecasts. Continued developments in information technology give much promise for large-scale integrated information systems that can potentially aid the human cognition and associated control action through the provision of effective, efficient, and explicable support for a variety of operational and strategic tasks. A top level goal for many within the society is to provide educational and research leadership that will enable people to better cope with complexity.

We do not underestimate the importance of the traditional disciplines and their role in systems engineering efforts. We are well aware, for example, that there is much to gain from a large number of new mathematical discoveries of the last three decades—especially in applied mathematics, statistics, and the mathematics of operations research. The challenge in this regard is to exploit this knowledge in the development of new computer simulation models that can be used by humans in ways that allow them to increase their intelligence through an increase in their skills of intuitive effect and reasoning by analogy, their heuristic rules used on familiar tasks, and their formal reasoning abilities in unstructured situations.

Research Areas Within the SMC Society

The preceding discussion has suggested a number of contemporary research areas. These concern systems engineering as an information science-based management technology that can do much, from a short and long range perspective, to resolve issues in organizations in general, and in industry and engineering in particular. Among these are

- multicriterion decision analysis
- decision support systems
- expert systems
- artificial intelligence and cognitive science
- behavioral and human factors in systems design
- economic systems analysis, time series, and forecasting
- stochastic optimization and control
- system simulation and modeling
- modeling and analysis under risk uncertainty and imprecision
- design of intelligent data bases
- queues and networks
- system maintainability and reliability
- software systems engineering
- management of research and development
- system acquisition and procurement
- computer assisted engineering design and management
- knowledge acquisition
- communication, command, and control
- strategic and tactical planning
- risk–benefit analysis of proposed technological innovations
- information environments of organizations
- evaluation of systems and processes
- system architecture
- robotics and intelligent machines
- pattern recognition
- intelligent programming and decision support generators.

There are numerous specific application areas for these studies. Each of them, however, is related by the common need to acquire, represent, and utilize knowledge in the resolution of issues that are often quite specific to particular areas. It is this provision of assistance in the organization of knowledge, such as to support diverse human activities, that is the goal of the information technology that is a central focus of effort for the Institution of Electrical and Electronics Engineers Systems Man and Cybernetics Society membership. We are certainly fortunate to live and practice our profession in these exciting times.