The IEEE Systems, Man, and Cybernetics Society: Historical Development, Current Status, and Future Perspectives

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***Abstract*—In the evolution of any professional organization, it is informative and desirable to take stock of what has occurred, and to use this assessment to consider and plan for the future. The IEEE Systems, Man, and Cybernetics (SMC) Society is considered to be the leading professional society in the transdisciplinary area of systems engineering, cybernetics, and human machine systems, and has an international reputation for our efforts in developing and presenting innovative research results related to this area. In this paper, we—group of five current and former SMC Society presidents—consider the past, present, and future of the IEEE SMC Society; we are also doing this to commemorate the Society's 30th anniversary. In particular, we address our auspicious beginning; our transition from an incubatee to an incubator society; the breadth of our transactions; the international character of our membership; the appropriateness of our name; the move toward an "intelligent" systems-oriented umbrella organization; the evolving array of research areas; and the challenges and opportunities we face in the future.**

***Index Terms*—Cybernetics, human machine systems, IEEE professional societies, SMC Society, systems engineering.**

I. Introduction

In this paper, we consider the past, present, and future of the IEEE Systems, Man, and Cybernetics (SMC) Society in order to better understand future trends in systems, humans, and cybernetics. Our consideration must, by necessity, be nonexhaustive. Indeed, we are but five out of a total of 18 current and former SMC presidents; our backgrounds, work experiences, and research endeavors do not completely encompass the broad range of SMC concerns; and our ability to look into the future is limited. Additionally, because of space limitation, we cannot comment on a number of other important issues. To a considerable extent, this paper is an update and extension of a previous paper on this subject [1] commemorating the Society's 20th anniversary.

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We begin with a brief discussion of the scope of SMC interests. The principal thrust of activities within the SMC is the development and use of the methods of *systems* engineering, together with the strongest of emphasis on hu*man*-system interaction concerns, for the design of knowledge-based *cybernetic* systems and processes that support human activities in planning, design, decision making, and associated resource allocation. It is through this thrust that we define a purpose of systems engineering as the organization of knowledge, which in turn requires methods for knowledge acquisition and representation, as well as utilization. Thus systems engineering activities—and the activities of the SMC—vary from requirements definition or specification, to the conceptual and functional design and development of systems; they are also much concerned with architectural definition and performance evaluation. These activities are needed to obtain functional integration, maintainability, reliability and, perhaps most importantly, the appropriate interfaces that will insure system design for successful human interaction—which may involve human supervisory control of physical processes, such as the robots that are used in automated manufacturing, including 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 SMC Society place major emphasis on behavioral factor concerns associated with *systems* engineering, to a variety of hu*man*–machine interaction issues, to a number of *cybernetics* issues related to communications, command and control in humans and machines. All of these are, and will be, especially concerned with the use of computers in decentralized, interactive, information repositories, as well as for the development of analytic, computational, and behavioral constructs that support the design of knowledge bases, model bases, and dialogue generation and management systems that, in turn, support *information technology-based systems and processes* for efficient and effective planning, design, and decision support through efficient and effective information and knowledge management.

II. SMC Today

Before we look at the beginnings of SMC, it is worthwhile to look at where SMC is today. Today, the SMC Society is considered to be the leading professional society in the field of systems engineering, cybernetics, and human machine systems, and has

TABLE I
PAST PRESIDENTS AND HISTORY OF SMC CONFERENCES

Year	Location	Conference Chair	Societv President
1971	Disneyland	Gary Hollander	William H. von Alven
1972	Washington	K. S. Narendra	John Warfield
1973	Boston	Ahmed Meer	Kan Chen
1974	Dallas	Andrew P. Sage	Thomas B. Sheridan
1975	San Francisco	L. Stephen Coles	Thomas B. Sheridan
1976	Washington	William H. Von Alven	Edward A. Patrick
1977	Washington	William H. Von Alven	Edward A. Patrick
1978	Tokyo/Kyoto, Japan	Michael S. Watanabe	James D. Palmer
1979	Denver	James D. Palmer	James D. Palmer
1980	Boston	Richard F. Vidale	S. Basheer Ahmed
1981	Atlanta	Robert P. Zimmer	S. Basheer Ahmed
1982	Seattle	James A. Wise	William B. Rouse
1983	Bombay/Delhi, India	Faqir C. Kohli	William B. Rouse
1984	Halifax, Nova Scotia	Mohammed El Hawari	Andrew P. Sage
1985	Tucson	William R. Ferrell	Andrew P. Sage
1986	Atlanta	William B. Rouse	G. V. S. Raju
1987	Alexandria	Andrew P. Sage	G. V. S. Raju
1988	Beijing/Shenyang, China	Jiang Xinsong/ Terry Bahill	Arye R. Ephrath
1989	Boston	Sheldon Baron	Arye R. Ephrath
1990	Los Angeles	Amos Freedy	James M. Tien
1991	Charlottesville	Chelsea C. White, III	James M. Tien
1992	Chicago	Richard Saeks	Chelsea C. White III
1993	La Touquet, France	P. Borne and M. G. Singh	Chelsea C. White III
1994	San Antonio	G. V. S. Raju	Madan G. Singh
1995	Vancouver	William A. Gruver	Madan G. Singh
1996	Beijing, China	Jim Chien	Donald E. Brown
1997	Orlando	James M. Tien	Donald E. Brown
1998	San Diego	Frank Dicesare	Richard Saeks
1999	Tokyo, Japan	Koji Ito	Richard Saeks
2000	Nashville	Kazuhiko Kawamura	Pierre Borne
2001	Tucson	Terry Bahill	Pierre Borne
2002	Hammamet, Tunisia	Abdel El Kamel	Michael H. Smith
2003	Washington D.C.	Jack Marin and Mengehu Zhou	Michael H. Smith
2004	The Netherlands	Wil Thissen	
2005	Hawaii	Mo Jamshidi	

an international reputation for presenting innovative research in its field of interest. The Society membership is currently over 4,400. SMC is now a global international society with about 61% of its members from outside the United States (25% from Asia, 26% from Europe, 10% from others). At the end of 2001, the SMC Society reserves were over $2M, about twice the yearly income of the Society, although this has decreased somewhat due, in part, to the current recession and associated financial issues within the IEEE. The major sources of income are publications and conferences.

SMC publishes its IEEE TRANSACTIONS ON SYSTEMS, MAN, AND CYBERNETICS in three parts: Part A, Systems and Humans; Part B, Cybernetics; and Part C, Applications and Reviews, currently about 2400 pages total. High interest in the field is indicated by the fact that paper acceptance ratios are about 25%. All SMC members receive Part C as part of their membership, and can also obtain Parts A and B for an additional fee. An electronic attachment option of Transactions, Part B, which allows software, MPEG movies, and additional data to be added to otherwise normal manuscripts, became available to members in 2001. This same option later became available for both Part A and Part C, in 2002, and now only electronic submission is encouraged for all three journals. Furthermore, SMC also is a technical cosponsor of several other IEEE journals. It is presently one of only a few IEEE professional societies where all of its journals are fully electronic on IEEE Manuscript Center and XPLORE. Most reviews are now accomplished electronically, and all three journals accept multimedia files as attachments. Soon, we will have multimedia abstracts.

SMC holds one major society annual conference, the IEEE International Conference on Systems, Man, and Cybernetics. This annual conference is currently held outside the U.S. every other year. An active student activity program is a part of each annual conference, which includes student paper awards, tutorials, and student attendance discounts. Finally, SMC also sponsors, co-sponsors, or has "in cooperation with" status with over 25 other conferences and workshops in 2002 and 2003.

Table I lists the presidents of the SMC since its founding and the location of the annual conferences and conference chairs. The SMC Society currently makes two major awards: the Norbert Wiener Award; and the Joseph G. Wohl Outstanding Career Award, which is the Society's senior award. Table II lists the recipients of these awards and the year of their receipt. There are also two outstanding paper awards: The Franklin V. Taylor

TABLE II
IEEE SMC MAJOR AWARD RECIPIENTS

Year	Wohl Award Recipient	Wiener Award Recipient
1980		Andrew P. Sage
1981		
1982		
1983		
1984		
1985		
1986		William B. Rouse
1987		
1988	Andrew P. Sage	Joseph G. Wohl
1989		
1990		
1991		Thomas. B. Sheridan
1992		
1993	James D. Palmer	Madan. G. Singh
1994		Jens Rasmussen
1995	Thomas B. Sheridan	Azriel Rosenfeld
1996		
1997	Lotfi Zadeh	
1998	James M. Tien	Pierre E. Borne
1999	Guenther Schmidt	Chelsea C. White III
2000	Madan G. Singh	Keith W. Hipel
2001	William B. Rouse	Yacov Y. Haimes
2002		Donald E. Brown

Award, for the best paper in the area of human machine systems, and the Andrew P. Sage Award, for the best paper in the SMC Transactions during the preceding year.

On November 14, 2001 a 33-page report on the status of the IEEE Systems, Man, and Cybernetics (SMC) Society was presented to the IEEE TAB Society Review Committee (SRC). Their observations and recommendations, in large part, were:

"SMC is a well managed, financially viable, and forward-looking Society. It is very aware of the need to be forward looking, and is duly cognizant of the potential impact of the current IEEE financial problems. Our suggestions are as follows:

- Seriously investigate the possibilities for expanding conference activities through the establishment of niche meetings/workshops/symposia, some of which may eventually become full conferences.
- Continue/pursue new initiatives in membership growth, student activities, continuing education, and new technical committee establishment.
- Many societies use their long-range planning committee to actively search out new areas of potential Society activity; such activity can often enthuse AdCom members who otherwise tend to be more inward-than-outward looking.

SMC leadership already recognizes these topics as important to its future, since they were expressed within their submitted report. SMC is encouraged to actively address its future; it is a particularly successful example of a medium-sized IEEE Society, and deserves to continue to serve its membership."

In this paper, we will first look at the history of the SMC Society, how and why it has grown (and changed), and then, we will examine some of the future possibilities for the society. By doing this, we will hopefully give some insight into what the future trends are for the interrelated fields of systems, humans, and cybernetics. While SMC is shaped by changes in these fields, SMC also influences how these fields develop. In addition to drawing heavily upon the article by Palmer, Sage, Sheridan, and Tien [1], we also rely strongly upon the works by Wohl [2] and Smith [3], [4] for some of the information and data contained in this paper. The reader is referred to these articles for further information.

III. AUSPICIOUS BEGINNING

The SMC Society was formally born in late 1970s by the merger of two groups in the IEEE–the Man–Machine Systems Group (then chaired by Joseph Wohl) and the Systems Science and Cybernetics Group (then chaired by Donald B. Brick). From the beginning, these two groups were oriented toward modeling over a broad spectrum of fields, ranging from the modeling of biological functions, to the modeling of large-scale socioeconomic systems with human–machine systems of all kinds in between. The members were largely researchers, in academe, or in industrial research laboratories, or in consulting firms. As noted, each group was concerned with the modeling of a broad spectrum of fields, ranging from biological functions to large-scale socioeconomic systems, albeit from different perspectives. Within these groups, most members were researchers, and it was felt that there was a need for an IEEE society that would focus on the intersection of these perspectives, e.g., the *intersection of technology and human functioning*. Thus SMC was born.

The Man–Machine Systems Group had its beginning in 1954. Frank V. Taylor, who had just organized Division 21 (now the Society of Engineering Psychologists) of the American Psychological Association and who had helped establish the Human Factors Society, and his colleague, Henry P. Birmingham, published an article on "Design Philosophy for Man–Machine Systems," in the *Proceedings of the Institute of Radio Engineers* (IRE, the predecessor to IEEE). Realizing that a closer link to engineers must be established in order for work on human factors to have an effect on hardware design, Hank Birmingham took the initiative in 1955 (against the advice of his colleagues in the Human Factors Society) to establish a professional group on human factors in electronics in the IRE. It became the 28th group in the IRE. Hank was chair of the group for the first year. Curt Jansky chaired it the second year. Bernard Mannheimer, John Senders, and Frank Taylor were early members. The first issue of the IRE *Transactions on Human Factors in Electronics* came out in March 1960; it was initially published aperiodically—that is, when enough good articles were received and refereed.

In 1968, the Professional Group on Human Factors in Electronics changed its name to the Professional Group on Man–Machine Systems in order to reflect the increasing interactions of humans in systems. By this time, the IRE had merged with the American Institute of Electrical Engineers to form the present IEEE. The first issue of the IEEE *Transactions on Man–Machine Systems* was dated March 1968. It was edited by Tom Sheridan, who also served as the first Chair of the Man–Machine Systems Group until the following year, when Joe Wohl became Chair of this predecessor group for what is today, the SMC Society.

The Professional Group on Systems Science and Cybernetics was organized in the early sixties. The first issue of its *Transactions* was published in November 1965, with Arthur D. Hall as its first editor. Early issues of the *Transactions* included important contributions by Hall, as well as, R. L. Ackoff, D. B. Brick, R. A. Howard, I. de Sola Pool, and L. Stark. Following the merger of the two IEEE groups, the first issue of the renamed *IEEE Transactions on Systems, Man, and Cybernetics* was published in January 1971 under the joint editorship of William R. (Russ) Ferrell and John Warfield. In January 1972, Andy Sage became the editor of the *Transactions*, a position he held until the end of 1998 at which time the *Transactions* had grown from a single part of approximately 600 pages to a three part journal of some 2,400 pages. In January 1999, three new editors assumed their roles: Chelsea C. (Chip) White for Part A, Systems and Humans, Krishna Pattipati for Part B, Cybernetics, and Madan G. Singh for Part C, Applications and Reviews. In January 2002, the editorships changed again with Donald E. Brown, Lawrence O. Hall, and Chip White assuming the role of Editor for Parts A, B, and C, respectively.

IV. SMCs Technical Committees

The areas covered by its technical committees reflect the scope of SMC. By looking at changes in the technical committees over the years, one can see how the focus within the scope of SMC has changed.

In 1971, the initial list of SMCs technical committees and their technical interests were:

Systems Science Committee:
- CADAR Representative
- IEEE Applications of Electrotechnolgy to Social Problems
- IEEE Environmental Quality Committee Representative
- IEEE Transportation Committee Representative
- National Priorities
- National Goals: Health Care
- Nonquantifiable Elements in Decision Making
- Optimization and Decision Analysis
- Problem Definition, Modeling and Simulation

Cybernetics Committee:
- Adaptive and Learning Systems
- Biocybernetics
- Foundation of Cybernetics
- Pattern Recognition

Man–Machine Systems Committee

By 1983, SMCs Technical Committees evolved to include new areas such as:
- Energy Systems
- Knowledge-based Systems
- Artificial Intelligence
- Control and Decision
- Adaptive and Learning Systems
- Technology Forecasting
- Technology Resources and Environment

By 1990, they evolved (and aggregated,) further such that new technical areas of interest were introduced, such as:
- International Stability
- Manual Control
- Optimization
- Pattern Recognition
- Image Processing
- Computer Vision
- Cognitive Systems Science and Engineering
- Human Decision-making
- Human–computer Interaction
- Information and Decision Systems
- Integrated Manufacturing

Currently, in December 2002, the SMCS had the following 23 Technical Subcommittees in the following general areas:

Cybernetics Committees:
- Adaptive Computing Systems
- Bio-informatics
- Computational Intelligence
- Expert and Knowledge Based Systems
- Intelligent Communications
- Knowledge Acquisition in Intelligent Systems
- Pattern Recognition
- Machine Learning
- Soft Computing

Human–Machine Systems Committees:
- Enterprise-wide Business Computing
- Human–Computer Interaction
- Human Interaction with Complex Systems
- Manual Control
- Socio-technical Systems Design

Systems Committees:
- Conflict Resolution
- Control of Uncertain Systems
- Discrete Event Systems
- Environmental Systems and Risk Analysis
- Industrial Applications
- Information Assurance
- Optimization
- Robotics and Manufacturing Automation
- Service Systems and Organization

One can see that over the years, areas such as Foundation of Cybernetics and National Goals: Health Care have disappeared while others such as Soft Computing and Robotics have emerged. Over the years, the focus within SMCs scope has shifted more and more into the areas involving “intelligent” systems.

SMC also interacts with other IEEE Societies and Councils by participating on their AdComs and committees. For example, SMC has two members on the IEEE Neural Networks Society AdCom. Many SMC Society members also cooperate with the Robotics and Automation Society and helped found the ITS Council, and recently, the Nanotechnology Council. SMC also has membership on the USAB and EAB committees and has had members serve as leaders within TAB. Furthermore, SMC members are also frequently involved in other societies, e.g., Circuits and Systems Society, Communications Society, Computer Society, Control Systems Society, Social Implications of Technology Society, American Institute of Aeronautics and Astronautics Society, INFORMS, NAFIPS, INCOSE, and the Human Factors and Ergonomics Society. SMC is a founding and continuing member of the Winter Simulation Conference.

These interactions strengthen the technical information exchange among these societies and enables SMC to deepen and enrich its particular fields of interest.

V. From an Incubatee to an Incubator Society

The IEEE SMC Society was incubated through the merger of two IEEE groups–Man–Machine Systems and Systems Science and Cybernetics. In turn, these two groups were born during the late 1950s and early 1960s because a significant body of intellectual ferment was brewing throughout the IRE, the AIEE, and subsequently, the IEEE. The essence of this concern centered on the fact that there was no place to air the efforts of engineers and engineering psychologists working at the intersection of technology and human functioning. Existing IEEE groups at the time generally eschewed publication of research papers on these topics in favor of "mainstream technological advances" such as, more mathematical treatises on the nuances and fine points of control theory. While these efforts were laudable in every way, they did not encompass the whole world of electrical engineering interests.

Given the manner in which the SMC Society was established, it is little wonder that it has become an incubator for related technological thrusts. We have only to examine the early list of SMCs Technical Committees above to come to this conclusion. This relatively short list of technical interests of the membership of the newly formed IEEE Group on Systems, Man, and Cybernetics in 1971 already showed sure signs of becoming an incubator organization. Of course, the hindsight afforded by several decades of seeing these things happen helps this visionary process. For example, we can track activities in health care, transportation, pattern recognition, and decision making and decision analysis. Pattern recognition has gone on to become Pattern Analysis and Machine Intelligence (PAMI) and has a life of its own as an IEEE technical interest activity complete with its own highly regarded *Transactions*. Yet another example is in simulation. For the technical interest area embodying simulation, SMC joined several other non-IEEE Societies to form the Winter Simulation Conference that publishes its own *Proceedings*, perhaps the most influential publication in the area of simulation. Unlike PAMI, the Winter Simulation Conference remains an integral part of SMC, and SMC remains as one of the founding member societies of the Conference's Board of Directors. So we may say that from the very beginning, this newly formed SMC Group, itself the result of having been within an incubator environment of sorts, has itself become a recognized incubator for new technologies at the cutting edge of engineering.

By the year 1983, we saw new SMC technical committees emerge in areas such as knowledge-based systems and artificial intelligence. These technical committees again acted as incubators, later leading to the development of an interest group in neural networks. Special interest groups in decision and control led naturally into an interest in robotics. First robotics and automation, and then neural networks have gone on to become separate IEEE entities, although supported by SMC as a sponsoring society. Today, they have become the IEEE Robotics and Automation Society and the IEEE Neural Networks Society.

VI. Breadth of Our *Transactions*

Since its inception in 1971, the *IEEE Transactions on Systems, Man, and Cybernetics* has published articles in a broad range of areas, including biocybernetics, biomedical systems, artificial intelligence, robotics, adaptive systems, large-scale socio-economic systems, man–machine systems, and systems science—all of which are based on Norbert Wiener's interdisciplinary cybernetics concepts which, to a large measure, originated in the development and planning of large hardware systems. Most SMC articles have been modeling-oriented. In general, systems are modeled as consisting of components, the salient governing equations of which could be identified. The components are then aggregated into subsystems and systems with various disturbance and goal inputs. There is little concern for describing the physics of the systems; the primary concern is system performance with respect to minimizing, or maximizing certain objective functions. Many model forms are found; these include stochastic, deterministic, decision-making, communication, control, pattern recognition, queuing, linear and dynamic programming, and economic models. Readers are expected to be mathematically sophisticated. However, the *Transactions* has never been interested in publishing purely mathematical papers. There has always been an implied requirement that models be focused on some ultimate and realistic application, even if experimental data were not offered, i.e., SMC has always focused on the *intersection of technology and human functioning*.

VII. Evolving Focus Within SMC's Scope Over Time

It is interesting to note how the focus within the scope of SMC has changed over the years. Hence, in order to better understand the current scope of papers in our *Transactions*, we have undertaken an analysis of the usage (frequency) of primary words taken from the titles of 237 actual papers published in the SMC *Transactions* over a 28-month period, from January 1990 through April 1992, and compared this to primary words taken from the titles of 237 papers published in 2000–2001. The results of this comparison are shown in Table III. The first column in Table III lists the primary words (other than prepositions and other simple nondescriptive words), sorted by frequency of occurrence during 1990–1992, that appeared more than five times in the 237 papers published in 1990–1992. The second column in Table III lists their frequency of use in 1990–1992. The third column lists their frequency of use in 2000–2001. The fourth column in Table III lists the primary words, sorted by frequency of occurrence during 2000–2001, that appeared more than five times in the 237 papers published in 2000–2001. The fifth column in Table III lists their frequency of use in 1990–1992. Finally, the sixth column lists their frequency of use in 2000–2001.

Whereas the word "systems" is still the primary word in published SMC papers, with a frequency of 60 words in 1992 and 47 words in 2001, it can be seen that significant changes have taken place. In 1992, the words optimal, automatic, visual, generalization, models, multiagent, support, image, navigation, pattern, reasoning, theory, coordination, functions, space, computational, experimental, flexible, manipulator, manufacturing, simulation, structural, architecture, complexity, fault, graph, search, and signal are no longer significantly represented. Instead, by 2001, they have been replaced by words that were not considered significant in 1992. These new words, which to some extent are also active areas of Society interest, are represented by the words control, adaptive, analysis, data, design, nonlinear, controller, genetic, optimization, performance, tracking, logic, selection, structure, function, management, neuro-fuzzy, and petri. Furthermore, it should be noted that while in 1992 the two major word usages were systems and robot, by 2001 they had changed to systems and fuzzy with control becoming a key new third area. Thus, as can be seen in the changes in the word usage over the years as shown in Table III, by 2001, *intelligent systems* have become an increasingly important and significant area for SMC.

From the above, it can be seen that SMC, and the field of systems, human, and cybernetics, has been moving away from nonperceptive and nonadaptive systems, and more toward intelligent systems. The greatest growth has been in the area of intelligent systems dealing with uncertainty and vagueness, i.e., "soft-computing" systems. Areas such as fuzzy logic, genetic algorithms, neural networks, and adaptive systems, which were relatively unexplored thirty or even ten years ago, are now dominating the scope of SMC. For example, in 1992, the word usage of systems was 60, whereas fuzzy was seven. Today, the word usage of systems is 47, and fuzzy is 41. In another ten years, what will the word usage be of today's emerging areas, as compared to traditional SMC areas?

Since 1971, SMC members have always had a professional interest in the closely interrelated fields of human–machine systems, systems science and engineering, and cybernetics. However, what has changed over time is that the tools available for designing, building, and implementing intelligent and complex systems have evolved from modeling crude approximations of such systems, to beginning to being able to model real-world systems, such as, complex control systems, financial systems, information systems, e.g., the Internet, and large scale social systems. Whereas in 1992, a typical title for a SMC paper might have been: "Distributed Dynamic Decision and Planning Systems for Robot Motion", today it might be: "An Adaptive Computationally Intelligent Control System Application Using a Fuzzy-Neural Network Algorithm."

It is difficult to predict what a typical title might be ten years from now. SMC is mainly a tool-making society; we react to new applications and theories created elsewhere. Hence while it may be possible to predict increased usage of evolutionary (emerging) areas, it is hard to predict revolutionary (brand new) ones.

Some examples, suggested to the authors of increasing future usage of evolutionary, or emerging areas are: odor source localization, image based control, e-commerce, distributed cooperative agents, intelligent control utilizing agents, integration of computer vision with image understanding, robots with new senses such as smell, cooperative data mining on large-scale repositories, computationally intelligent and efficient neural networks for temporal data, more biologically oriented neural networks, cybernetic systems in the field of bio-informatics, nanotechnology, hybrid systems using fuzzy logic, etc.

TABLE III
WORD USAGE IN TITLES OF SMC PUBLISHED PAPERS

Word Sorted by 1992 Usage	1992	2001	Word Sorted by 2001 Usage	1992	2001
systems	60	47	systems	60	47
robot	27	11	fuzzy	7	41
based	24	15	using	10	35
network	24	25	control		32
distributed	23	6	network	24	25
knowledge	17	7	algorithms	9	23
approach	16	16	neural	10	20
decision	16	12	approach	16	16
motion	16	9	based	24	15
dynamic	15	10	adaptive		14
optimal	15		applications	9	14
planning	15	6	intelligent	13	14
automatic	13		model	11	14
information	13	12	analysis		12
intelligent	13	14	decision	16	12
method	13	6	information	13	12
visual	12		learning	6	12
generalization	11		modeling	8	12
integration	11	5	data		11
model	11	14	design		11
models	11		robot	27	11
multiagent	11		dynamic	15	10
process	11	5	detection	9	9
support	11		motion	16	9
neural	10	20	nonlinear		9
using	10	35	agents	6	8
algorithms	9	23	problem	8	8
applications	9	14	controller		7
detection	9	9	genetic		7
image	9		knowledge	17	7
navigation	9		new		7
pattern	9		optimization		7
reasoning	9		performance		7
theory	9		recognition	8	7
coordination	8		tracking		7
functions	8		diagnosis	6	6
modeling	8	12	distributed	23	6
problem	8	8	logic		6
recognition	8	7	method	13	6
space	8		planning	15	6
computational	7		selection		6
experimental	7		structure		6
flexible	7		function		5
fuzzy	7	41	human	7	5
human	7	5	integration	11	5
manipulator	7		management		5
manufacturing	7		neuro-fuzzy		5
simulation	7		novel		5
structural	7		petri		5
agents	6	8	process	11	5
architecture	6		optimal	15	
complexity	6		automatic	13	
diagnosis	6	6	visual	12	
fault	6		generalization	11	
graph	6		models	11	
learning	6	12	multiagent	11	
search	6		support	11	
signal	6		image	9	
control		32	navigation	9	
adaptive		14	pattern	9	
analysis		12	reasoning	9	
data		11	theory	9	
design		11	coordination	8	
nonlinear		9	functions	8	
controller		7	space	8	
genetic		7	computational	7	
new		7	experimental	7	
optimization		7	flexible	7	
performance		7	manipulator	7	
tracking		7	manufacturing	7	
logic		6	simulation	7	
selection		6	structural	7	
structure		6	architecture	6	
function		5	complexity	6	
management		5	fault	6	
neuro-fuzzy		5	graph	6	
novel		5	search	6	
petri		5	signal	6	

What we are seeing today is that the multifarious nature of SMC is its strength. This nature has lead to 31 years of continuously evolving hybrid systems, whereby emerging technologies, as well as revolutionary ones, are combined with existing

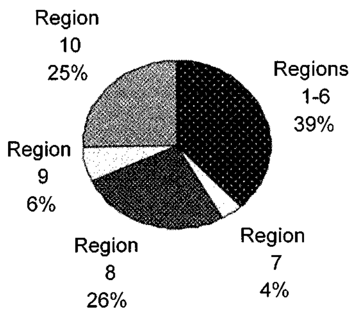

Fig. 1. IEEE SMC membership by regions.

techniques to develop innovative systems modeling and systems management advances.

VIII. International Character of Our Membership

While the IEEE itself is an international organization, with some 37.6 percent of its 377 342 members (as of December 2001) being located outside of the U.S., we note with pride that the comparable figure on this date for the SMC Society, with a total membership of 4,438) was 60.3 percent. More specifically, and in terms of the four non-U.S., IEEE regions, the 60.3 percent was distributed as follows: 3.4 percent in Region 7 (i.e., Canada), 26.3 percent in Region 8 (i.e., Europe, Africa and Russia), 5.9 percent in Region 9 (i.e., South America), and 24.7 percent in Region 10 (i.e., Asia and Pacific Rim). Fig. 1 presents this membership data in graphic form for the ten IEEE Regions. Thus, both the IEEE and SMC are very international societies. In May 1990, the comparable percentages for the then 287 557 member IEEE was 22.2 percent located outside of the U.S., whereas for the 4,819 member SMC Society, it was 40.6 percent, thereby indicating a growth in international membership for both entities. We welcome this situation. Because of this, SMC has changed its conference policy so that SMCs annual international conference is now held outside the U.S. every other year.

To better serve this objective, an ad-hoc committee was recently established to identify key groups of non-U.S. members who might be interested in hosting future SMC conferences. As another example, we might want to continually assure a governance structure that is reflective of our international character, including our present practice of electing non-U.S. members as AdCom members and officers of our Society. A third area where we should be continually sensitive to our international character is in member services. At a meeting in June 1990, the IEEE Technical Activities Board (TAB) voted to establish its first non-U.S. office in Brussels, Belgium. SMC supported this action, with the expectation that our Region 8 members would then soon experience enhanced member services. This has, we believe, occurred and non U. S. based membership increases over the last decade reflect this mightily. Since 60% of SMCs members and officers are global in nature (e.g., 60% live outside the U.S), SMC can say that it really does represent the international needs and research interests of engineers and scientists from around the world; a claim that only a few IEEE societies can make at this time.

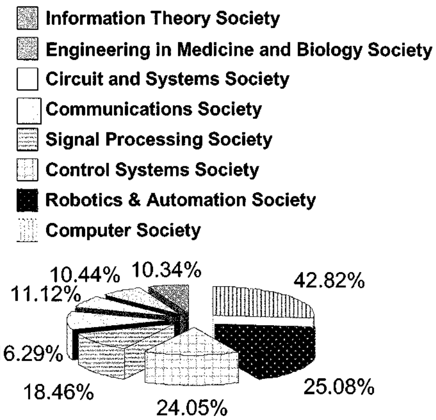

Fig. 2. Percentage of SMC Members who belong to other IEEE Societies (i.e., societies to which more than 10% of SMC members belong).

The SMC Society has somewhat common interests with a number of other societies. Often SMC attracts members who look at more that one aspect of systems science or cybernetics. SMC members tend to work on broader problems with a wider range of tools than many members of other societies that are often more specifically focused. This explains why most of SMCs members hold more than one membership in IEEE societies. In late 2001 for example, 42.82% of SMC members also held membership in the IEEE Computer Society, 25.08% in the Robotics & Automation Society, 24.05% in the Control Society, and 18.46% in the Signal Processing Society. Fig. 2 presents this data. Finally, while the SMC Society has members drawn from many professional employment areas, those from academia represent the clear majority of the membership.

IX. Evolving Array of Research Areas and Opportunities

The techniques and concepts which underpin the fields of systems, humans, and cybernetics are evolving, especially as new technologies evolve and emerge. Many of the SMC-related research efforts involve the information technologies. An objective that supports all of these efforts is the continued development of systems engineering as an information-science and information systems-based discipline. Much of traditional engineering activity within the IEEE has been concerned with the physical and materials sciences. Today is clearly the age of large scale systems in which information and associated knowledge serve not only as the "glue" that holds the system together but which also provide its competitive advantage. Systems engineering and information systems engineering complement and enhance traditional engineering activities through their emphasis on information as a basis for engineering. Systems engineering efforts allow the integration of the *information basis* for engineering with the traditional *physical basis* for engineering so as to enable the design of technological systems and processes that provide effective, efficient, and explicable support to humans in strategic planning and management control, often of a real time nature, of operations and tasks. Tien [5] calls this area of real time information-based decision making through his use of the term "decision informatics."

In systems engineering, and within the SMC Society, we are especially concerned with aiding clients in the organization of knowledge for such purposes as design, and we realize that initiative and creativity are best enhanced when the user of an information system is able to self direct the system toward *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 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 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.

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, be involved in issue resolution efforts. This brings about yet further 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 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, especially as this relates to information technology-based support systems that ameliorate the effect of human error—which will always be with us.

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, the mathematics of operations research, and soft computing. The challenge in this regard is to exploit this knowledge in the development of new computer simulation models that can help humans increase their intuitive reasoning by analogy, their heuristic rules for familiar tasks, and their formal reasoning abilities in unstructured situations. Doubtlessly, it is for this reason that modeling, including the development of models of approximate reasoning activities, has become such an important part of SMC efforts.

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. Obviously, these subject areas are interrelated. And, there are numerous specific research endeavors within each subject area. Each endeavor, however, is related by the common need to acquire, represent, and utilize knowledge in the resolution of issues. It is this provision of information-based assistance in the organization of knowledge and the communication of this knowledge that is the goal of information technology, and is a central focus for the membership of the IEEE SMC Society. We are indeed fortunate to live and practice our profession in these exciting times.

X. Appropriateness of Our Name

Systems, *humans*, and *cybernetics* are the three primary fields of interest of the IEEE SMC Society. Even these three words represent a sort of shorthand for lengthy terms. The word *systems* is used as shorthand for *systems engineering*. Sage [6], [7] and Sage and Rouse [8] relate systems engineering to the methods and tools of systems engineering, the systems and design and development processes that can be employed to produce a system of large scale and scope, and the systems management processes needed to insure that an overall systems engineering effort is trustworthy in terms of both process and product. The word *man* in SMC is used to imply system design for human interaction. That is to say, systems engineering that is human oriented. This requires that humans participate in setting forth design requirements and that system designs are such that humans can effectively interact with them. The term *cybernetics* relates to command, control, and communication among humans and machines such that the ultimate human–machine combination is well suited to its intended purpose.

Clearly, *systems*, *man*, and *cybernetics* are terms that have served us well during the past three decades; they have appropriately described our broad range of interest areas. But, do these terms appropriately characterize our efforts today and beyond, as we make further progress in the twenty-first century? As noted earlier in our analysis of SMC paper titles, the term *systems* is indeed very much used, quite often to represent intelligent systems and systems that include humans as well as technological components, while the terms *man* and *cybernetics* are used quite infrequently. Moreover, as we become more sensitive to "politically correct" terms, should we not consider substituting the more generic term *human* for *man*? In regard to substituting for *cybernetics*, there are other terms that might better describe our Society's current and future interests. Computational intelligence would potentially be a much more appropriate term; and one that is often used within the SMC Society, and elsewhere, to include cybernetics.

XI. Future of Challenges and Opportunities

Over the years, SMC has retained its broad perspective and its role as an incubator society. We have stoutly resisted becoming narrowly focused on any one application (as is true of many of the other IEEE societies) or on any single modeling approach (as has been perhaps true of, say, the *Transactions on Automatic Control*). This has probably cost SMC some membership, particularly among those engineers and scientists who are not clear on what we stand for or what is our specific focus. A broad interest in systems modeling, particularly those with human components in some form, can be rather confusing for many engineers who would prefer to deal with exclusively technological systems. At the same time, we are a haven for modelers and systems professionals who do not necessarily fit neatly and exclusively in one of the many other IEEE Societies.

Our opinion is that SMC should hold the course, that it has unique and valuable contributions to make in its present form, and that there is no purpose to be served in forcing it to change its nature. Fashions will come and go, and there are inherent dangers in chasing the latest fad. New fields will evolve, and in some cases, break off part of our own membership and carry it along into a new society. This has already happened, for example, where neural networks has become the IEEE Neural Networks Society, and also with fuzzy logic growing into a number of non-IEEE societies (with many IEEE societies having overlaps in fuzzy logic), or with information technology and decision sciences—if it is not already happening. However, SMC should vigorously pursue the activities that interest its members, so as to continue to be the premier IEEE Society for those technical areas. While not interfering with the formation of new societies, we should not be shy about "claiming the turf" in those areas in which we are strong. This should include, for example, intelligent systems, neural networks, fuzzy logic, decision theory, human–computer interactions, and large scale socio-economic modeling.

There is no dearth of challenges and opportunities facing SMC. The U.S. and the world are confronted with many serious problems. All of these have predictable components which can be modeled in one way or another, and therefore, policy alternatives can be explored. As examples, the following issues, problems, and associated needs are among those confronting the world today.

- ***Environment***. Developed nations use energy and chemicals which pollute their air and water and consume nonrenewable resources. Developing nations are emulating them, cutting down the rain forests, and generally exacerbating the situation. Greenhouse gases seem to be raising the temperature of the planet, posing long-term threats of unknown nature and magnitude.
- ***Automation, productivity, and industrial infrastructure***. Many countries are not willing to make long-term investments in industrial infrastructure innovations, such as automation and robotics, to improve their productive capacity. Instead of investment in the future through sacrifice and proper planning in the present, they try to protect their jobs and current way of doing business
- ***Education***. Standards of basic education continue to decline in many countries, particularly in science and math. Yet many countries often seem unwilling to pay for education. As a result, young people are often ill-matched to an ever demanding employment need.
- ***Health***. Health costs continue to rise relative to other costs, in part, because as new technology is developed, everyone feels they have a right to it, whatever the cost. Allocations of relatively scarce health resources will be a growing problem for many countries.
- ***Criminal and civil justice***. Dealing with national and international forms of terrorism is a major contemporary need.
- ***Air and ground transportation***. Capacities of airports serving metropolitan areas have reached their limits. Rush hour congestion has made urban highway systems into parking lots. Electronic technology is now being applied to both these transport modes to squeeze more traffic through by reduced headways and tighter, and to some degree automatic, controls.
- ***Discrepancies between the rich and the poor***. On a world-wide basis perhaps the greatest threat of all is the growing discrepancy between the rich and the poor nations, both because of economic forces and because of differential population growths. The latter naturally want what the former have, and whether it comes in the form of illegal immigration, isolated terrorism, or growing nuclear capability, the poor will demand better treatment. Old fashioned military strength is no longer sufficient to maintain the security of the rich nations, especially since alliances and arms sales, and terrorist threats [9] can change the delicate balance so rapidly.
- ***Critical technologies***. Just over a decade ago in the U.S., the National Critical Technologies Panel [10] identified 22 technologies that it considered essential to the nation's long-term security and economic prosperity. They included technologies in materials (i.e., materials synthesis and processing, electronic and photonic materials, ceramics, composites, and high-performance metals and alloys), manufacturing (i.e., flexible computer integrated manufacturing, intelligent processing equipment, micro- and nanofabrication, and systems management technologies), information and communications (i.e., software, microelectronics and optoelectronics, high-performance computing and networking, high-definition imaging and displays, sensors and signal processing, data storage and peripherals, and computer simulation and modeling), biotechnology and life sciences (i.e., applied molecular biology and medical technology), aeronautics and surface transportation; and energy and environment (i.e., energy technologies and pollution minimization, remediation, and waste management). More contemporary studies identify essentially these needs, as well. While the development of new technologies can surely improve the welfare of our peoples, we also recognize that technology is not the only answer, and indeed if not carefully designed, implemented, and managed, technologies can serve to widen the gap between rich and poor and impart other effects which are detrimental in the long run [11]. Hence this need is also associated with the need for improved methods of technology assessment, another field in which SMC has contributed much. Closely related to this is the need for greater attention to service sector technologies. Tien and Berg [12] and among those who have made a call for enhanced efforts at Service

Systems Engineering. Increased attention to human and automation concerns [13] is also a major need.

- *The Information Technology Revolution*. Last, but by no means least, on this list is the growing need to deal with the rapidly emerging technologies of computers and communications, and the use of these in almost all areas of society to enhance information acquisition, representation, storage, transmission, use, and knowledge, which is information embedded in appropriate context. There are major contemporary issues here, and they range from better use of knowledge and information, and include such issues as large scale data mining to get relevant information as we are being bombarded with massive information with most of it being either incorrect, not relevant, or almost impossible to find. Development of computational intelligence as a knowledge based endeavor is a major activity of many SMC members and is much associated with information technology based concerns that affect people, processes, policies, and products. The Internet, and how it has and will affect people's lives, is a major illustration of the evolution of information technology over the last few years.

These are but a few of the problems we all face now and in the future. They are complex dynamic systems problems in which emergence and adaptation are to be expected, surely amenable to modeling, computer simulation, prediction and policy decision—the special capabilities of SMC members. In this sense, SMC faces a future of challenges and opportunities in such strongly focused interest areas as intelligent systems. We, along with our colleagues in related fields, welcome these challenges and opportunities. Today, because of the efforts of such visionaries as the founders of the society, and its continuing efforts, the SMC Society remains a strong and vital organization. As we look toward the future, we can do no better than to go back to the beginning and emulate our founders. So long as we remain true to our earliest objectives of being a "scientific, literary, and educational" society [14], and maintain our lively interest in emerging and cutting-edge technologies, SMC will continue to provide the invaluable service that it has given to its profession and to humankind.

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